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Water-Supply and Irrigation Paper No. 130 Series P, Hydrographic Progress Reports, 35

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

BY

CYRUS C. BABB and JOHN C. HOYT

PART VII.—Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River Drainages

WASHINGTON

GOVERNMENT PRINTING OFFICE

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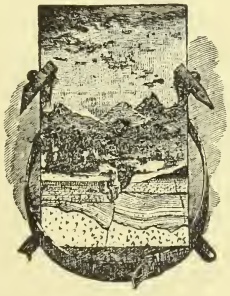

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., April 20, 1905.

SIR: I transmit herewith the manuscript of Part VII of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of Mississippi River.

The larger part of the original data for this report was collected under the direction of C. C. Babb, district engineer, who was assisted by A. E. Place, L. R. Stockman, Robert Follansbee, and W. B. Freeman. A portion of the data given herein was collected under the direction of M. C. Hinderlider and E. Johnson, jr., as noted in the acknowledgments. The assembling of the data and their preparation for publication were done under the direction of J. C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, W. E. Hall, and F. H. Tillinghast.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART VII.

By Cyrus C. Babb and John C. Hoyt.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	20,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000
Year ending June 30, 1906	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observations.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations; and second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag-line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is swift some appli-

MAP OF THE UNITED STATES, SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1904.

ance—generally a secondary cable—is necessary to hold the meter in position below the surface.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated, and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. Great care is taken in the selection and equipment of gaging stations, in order that the data may have the required degree of accuracy.

On many of the larger rivers where water power is developed by dams estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

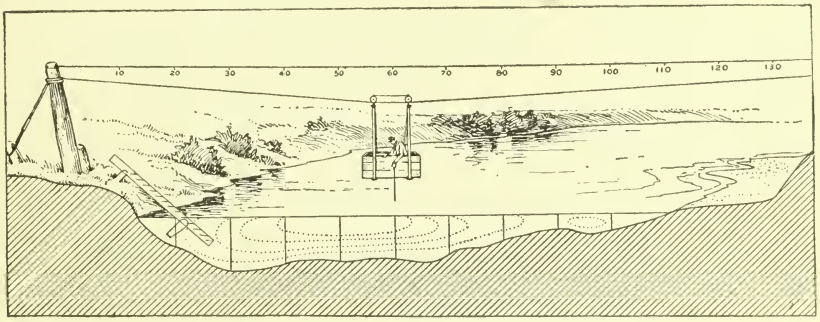


FIG. 1.—Cable station, showing section of river, car, gage, etc.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined. After years of experience the Survey has adopted the Price current meter for general work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface slope, wetted perimeter, and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

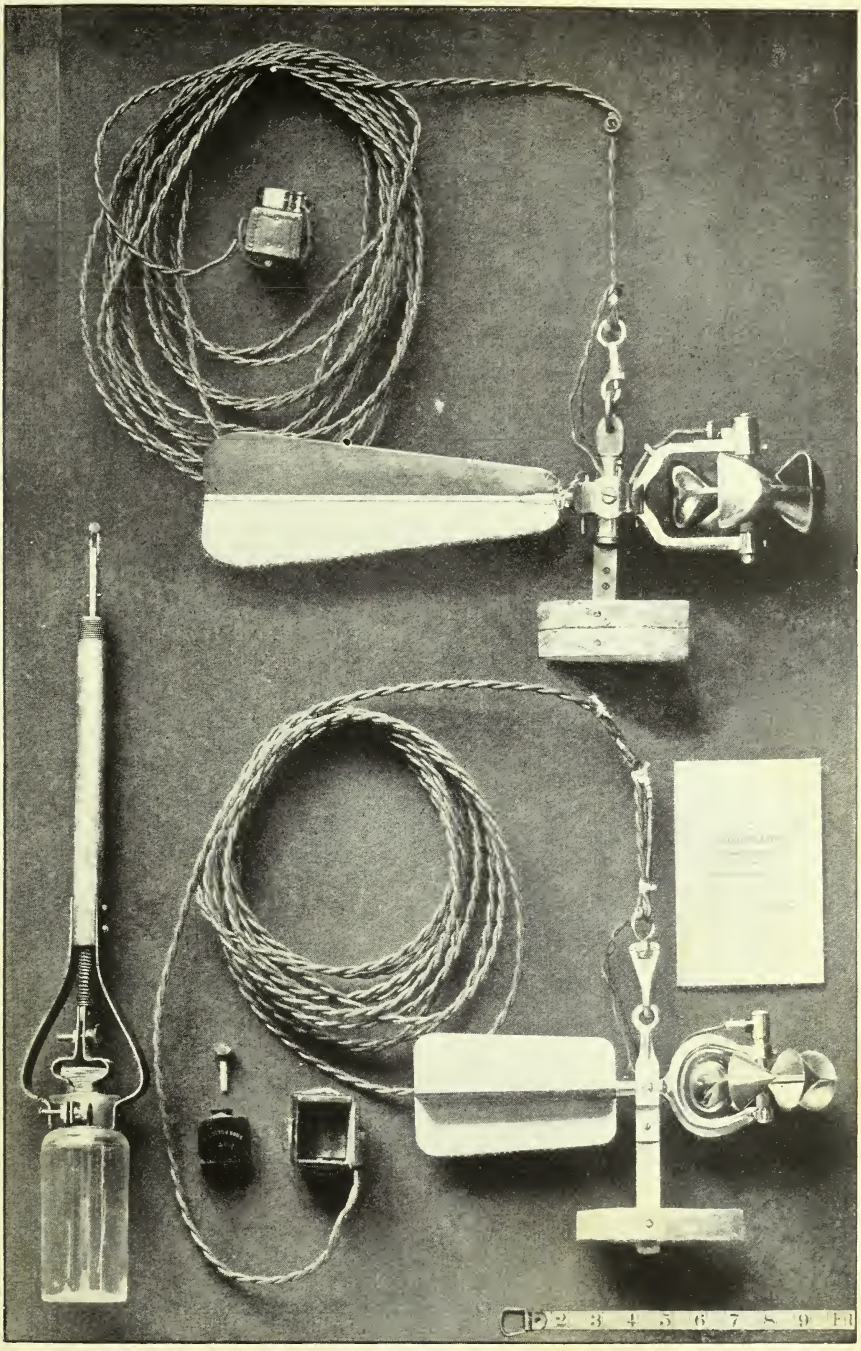
In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points

are usually at regular intervals varying from 2 to 20 feet, depending upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and soundings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth, for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenth depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at six-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between .94 and 1.04, with a mean for the 910 observations of 1.00. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from .85 to .95, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity-curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth into the area bounded by this mean velocity-curve and the initial line. Owing to the length of time it takes to make these measurements, they



PRICE CURRENT METERS, WITH BUZZERS.

are seldom used except for determining coefficients for purposes of comparison, and for measurements under ice.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple-point method the meter is held at mid depth, at 0.5 foot below the surface and at 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity, twice the mid-depth velocity, and the bottom velocity, by 4.

The vertical-integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The "acre-foot" is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot; 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow per second.

The base data for computing the daily discharge of a stream are the daily gage heights and the various discharge measurements, of which there should be sufficient number to cover the range of stage. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights. (2 and 3 depend on 1.)

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent or practically permanent beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds, the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas. Through these points a smooth curve is drawn, which shows the discharge for any gage height, and from which a rating table is prepared.

The mean velocity and area determined for each discharge measurement are also plotted. Through these points the curves of mean velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value in determining the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half-tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station rating curve, the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character, the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made, the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and the Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes occur.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are taken either by integration in verticals or by the vertical velocity-curve method, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part VII, is published in a series of twelve

Water-Supply Papers, Nos. 124–135, inclusive, under the following subtitles:

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.
Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.
Part 4. Santee, Savannah, Ogeechee, Altamaha rivers, and Eastern Gulf of Mexico drainages.
Part 5. Eastern Mississippi River drainage.
Part 6. Great Lakes and St. Lawrence River drainage.
Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.
Part 8. Platte, Kansas, Meramec, Arkansas, and Red River drainages.
Part 9. Western Gulf of Mexico drainage.
Part 10. Colorado River and the Great Basin drainage.
Part 11. The Great Basin and Pacific Ocean drainages in California.
Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations and such other information that has been collected that has a direct bearing on these data, including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage heights gives for each day the mean height of the surface of the river as found from the mean of the gage readings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" gives the average flow for each second during the month. Upon this mean the computations for the two remaining columns which are defined on page 14 are based.

In the computations for the tables of this report the following rules have been used in general:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should in general be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals, where the first significant figure is preceded by one or more naughts (0), when the quantity

shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications. A detailed index of these reports (from 1888–1903) is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of Mississippi River, Water-Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at prices little above cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Iowa.—District hydrographer, E. Johnson, jr.,[a] assisted by F. W. Hanna, assistant engineer. Acknowledgment should be made to Frank Dearborn, Stone City, Iowa, who assisted in establishing a gage at Stone City, and supplied voluntary readings for the same.

Kansas.—Resident hydrographer, W. G. Russell.[b] Acknowledgments are due the Atchison, Topeka and Santa Fe; Union Pacific; Missouri, Kansas and Texas; and Chicago, Rock Island and Pacific railway companies for annual passes issued to Mr. Russell.

Minnesota.—District hydrographer, E. Johnson, jr.,[a] assisted by F. W. Hanna, assistant engineer.

Missouri.—District hydrographer, E. Johnson, jr.,[a] assisted by F. W. Hanna, assistant engineer. Acknowledgments should be made to the St. Louis and San Francisco Railroad for transportation furnished to Mr. Hanna between St. Louis and Arlington, Mo., and to George B. Mainprize for voluntary observations at Greer Springs, Greer, Mo.

Montana.—District engineer, C. C. Babb,[c] assisted by A. E. Place, L. R. Stockman, and Robert Follansbee, assistant engineers, and W. B. Freeman, engineering aid.

Nebraska.—Resident hydrographer, J. C. Stevens.[b] Valuable assistance was rendered by Prof. O. V. P. Stout, of the University of Nebraska, in the way of the free use by the resident hydrographer of office facilities and suggestions in the methods for the collection of field data. Acknowledgments are also due the Chicago, Burlington and Quincy; Chicago and Northwestern; and Fremont, Elkhorn and Missouri Valley railroads for annual passes issued in favor of Mr. Stevens.

North Dakota.—District hydrographer, E. Johnson, jr.,[a] assisted by E. F. Chandler, of the engineering department of the University of North Dakota.

South Dakota.—Resident hydrographer, R. F. Walter,[b] assisted by F. M. Madden, engineering aid.

Wyoming.—The hydrographic work in this State has been carried on under the direction of the district hydrographer, M. C. Hinderlider,[b] and by the resident hydrographer, A. J. Parshall. Acknowledgments are due for annual passes over all their lines in Wyoming to the Union Pacific; Chicago, Burlington and Quincy; Colorado and Southern; Colorado and Wyoming; and Fremont, Elkhorn and Missouri Valley railroads.

HUDSON BAY DRAINAGE BASIN.

Red River drains a large basin in the United States, covering portions of Minnesota and North and South Dakota, characterized by a level topography, broken up in places by moraines and other glacial deposits. The major part is prairie, and its eastern half has an abundance of lakes and some woods. The main river flows nearly due north, cutting a deep channel in its broad, level valley, and is subject

[a] The office of the district hydrographer for Iowa, Minnesota, Missouri, and North Dakota is 876 Federal Building, Chicago, Ill.

[b] The office of the district hydrographer for Kansas, Nebraska, South Dakota, and Wyoming is Chamber of Commerce Building, Denver, Colo.

[c] The office of the district engineer, in charge of hydrographic work in Montana, is Browning, Teton County, Mont.

to sudden rises caused by heavy spring rains, entailing frequently considerable loss of life and property. The valley of Red River comprises about 9,000,000 acres of excellent agricultural lands, which to a large extent still await settlement. A number of water powers have been developed during recent years on the tributaries entering from both sides.

Red River drains into Hudson Bay through Lake Winnipeg and Nelson River. Red Lake River, one of its principal tributaries in Minnesota, drains Red Lake in the northern part of the State. Sheyenne River, its principal tributary from North Dakota, joins Red River about 10 miles below Fargo, N. Dak.

St. Mary River heads in northern Montana, near the Canadian boundary line, on the eastern slope of the main range of the Rocky Mountains, in a region of perpetual snow and in the midst of numerous glaciers. It starts from the great Blackfoot Glacier (probably the largest in the Rocky Mountains within the United States) and receives affluents from at least a dozen lesser ones. These small streams unite within a short distance from their sources and flow into a lake hemmed in by high mountains, known as Upper St. Mary Lake. Below this, separated by a narrow strip of land, is Lower St. Mary Lake. The aggregate length of these two lakes is about 22 miles. The river flows out of the lower lake, the elevation of which is 4,460 feet above sea level, and within 2 miles is joined by a stream nearly if not quite as large as itself, known as Swift Current Creek, which receives the water of the Grinnell Glacier and four lesser ones. From the confluence of these streams to the boundary of the British possessions, a distance of 12 miles, the river flows in a northerly direction. Kennedy Creek is a small tributary entering St. Mary River a few miles before the latter crosses the Canadian boundary. Entering Alberta it empties into Belly River, its waters at length finding their way through Saskatchewan River into Hudson Bay. A canal has been constructed in Canada by the Canadian Northwest Irrigation Company which diverts water from the right bank of St. Mary River about 5 miles below the international boundary line.

ST. MARY RIVER NEAR ST. MARY, MONT.

This station was established April 9, 1902, by J. S. Baker. It is located on Henry Henkel's ranch, about 1 mile east of his house, and is 35 miles northwest of Browning, Mont. It is also about 4,500 feet below Lower St. Mary Lake. The gage, which is located about 1,000 feet above the cable from which the measurements are made, is of the wire type. It is supported upon a horizontal arm which extends over the river and is fastened to a cottonwood stump. The scale board is graduated to feet and tenths. The length of the wire from the bottom of the weight to the marker is 11.40 feet. A new wire gage was

installed by C. T. Prall, June 17, 1903. It reads the same and has the same length of wire as the 1902 gage. The gage is read once each day by Henry Henkel, who lives about 1 mile west of the station. Discharge measurements are made by means of a cable, car, and tagged wire. The cable is fastened to a cottonwood tree on each bank. The initial point for soundings is on the left bank at the middle of the cot tonwood tree to which the cable is fastened. The channel is straight for 500 feet above and for 200 feet below the station. Both banks are high and rocky and have gentle slopes. The current has a moderate velocity. The bed of the stream is composed of gravel and bowlders. Bench mark No. 1 is a spike in the foot of a cottonwood tree 30 feet north of the gage. It is marked B. M. 9.24, denoting its elevation above gage datum. Bench mark No. 2 was a wire spike in the rear post of the gage, and was marked B. M. 6.97. Its elevation above gage datum was 6.97 feet. This bench mark has been destroyed. Bench mark No. 3 is a 60-penny spike in the base of a cottonwood tree 125 feet above the gage. Its elevation is 9.61 feet above gage datum.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of St. Mary River near St. Mary, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 9	L. R. Stockman	91	202	4.34	3.13	878
June 8	W. B. Freeman	101	360	5.91	4.73	2,130
July 11	Robert Follansbee	100	309	5.73	4.30	1,771
July 29	W. B. Freeman	96	202	4.21	3.20	851
August 31	do	87	135	3.27	2.42	441
November 18	L. R. Stockman	49	46	1.34	1.25	62

Mean daily gage height, in feet, of St. Mary River near St. Mary, Mont., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					3.00	4.30	4.30	3.00	2.40	1.90	1.50	1.30
2					3.10	4.30	4.30	3.00	2.40	1.90	1.50	1.20
3				1.00	3.20	4.40	4.30	3.00	2.30	1.90	1.50	1.20
4				1.00	3.20	4.40	4.40	3.00	2.70	1.90	1.50	1.20
5				1.00	3,20	4.40	4.40	3.00	2.30	1.90	1.40	1.20
6				1.00	3.20	4.50	4.40	3.00	2.30	1.90	1.40	1.20
7				1.00	3.10	4.50	4.40	3.00	2.30	1.90	1.40	1.20
8				1.10	3.10	4.60	4.40	3.00	2.30	1.90	1.40	1.20
9				1.10	3.10	4.70	4.40	3.00	2.30	1.90	1.40	1.20

[a] River frozen from January 1 to 10 and from January 20 to April 3, when ice went out.

Mean daily gage height, in feet, of St. Mary River near St. Mary, Mont., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
10	.....	.....	.....	1.10	3.10	4.70	4.40	3.00	2.30	1.80	1.30	1.20
11	1.80	.....	.....	1.10	3.10	4.70	4.40	3.00	2.30	1.80	1.30	1.20
12	1.80	.....	.....	1.20	3.00	4.60	4.30	3.00	2.20	1.80	1.30	1.20
13	1.80	.....	.....	1.20	3.00	4.40	4.30	3.00	2.20	1.80	1.30	1.20
14	1.70	.....	.....	1.30	3.00	4.20	4.30	3.00	2.20	1.80	1.30	1.20
15	1.70	.....	.....	1.30	3.10	4.30	4.30	2.90	2.20	1.80	1.30	1.20
16	1.60	.....	.....	1.40	3.10	4.40	4.10	2.90	2.10	1.80	1.30	1.20
17	1.50	.....	.....	1.40	3.10	4.40	3.90	2.80	2.10	1.80	1.30	1.20
18	1,50	.....	.....	1.40	3.20	4.60	3.70	2.80	2.10	1.80	1.30	1.20
19	1.50	.....	.....	1.40	3.30	4.60	3.60	2.70	2.10	1.80	1.30	1.20
20	.....	.....	.....	1.80	3.40	4.80	3.50	2,80	2.10	1.70	1.40	1.20
21	.....	.....	.....	2.10	3.60	4.90	3.30	2.80	2.10	1.70	1.50	1.20
22	.....	.....	.....	2.40	4.00	4.80	3.20	2.80	2.10	1.70	1.50	(a)
23	.....	.....	.....	2.50	4.20	4.80	3.20	2.70	2.00	1.70	1.50	.....
24	.....	.....	.....	2.50	4.40	4.70	3.10	2.70	1.90	1.60	1.40	.....
25	.....	.....	.....	2.50	4.60	4.70	3.10	2.60	1.90	1.50	1.30	.....
26	.....	.....	.....	2.50	4.60	4.50	3.10	2.50	1.90	1.50	1.30	.....
27	.....	.....	.....	2.60	4.40	4.20	3.10	2.40	1.90	1.50	1.30	.....
28	.....	.....	.....	2.60	4.30	4.20	3.10	2.40	1.90	1.50	1.30	.....
29	.....	.....	.....	2.70	4.20	4.20	3.20	2.30	1.90	1.50	1.30	.....
30	.....	.....	.....	2.90	4.20	4.20	3.10	2.30	1.90	1.50	1.30	.....
31	.....	.....	.....	.....	4.30	.....	3.00	2.40	.....	1.50	.....	.....

(a) River frozen.

Rating table for St. Mary River near St. Mary, Mont., from April 9, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.00	20	2.10	335	3.20	950	4.60	2,110
1.10	33	2.20	375	3.30	1,020	4.80	2,295
1.20	50	2.30	420	3.40	1,090	5.00	2,490
1.30	72	2.40	465	3.50	1,160	5.20	2,700
1.40	98	2.50	515	3.60	1,235	5.40	2,920
1.50	127	2.60	565	3.70	1,315	5.60	3,160
1.60	158	2.70	620	3.80	1,395	5.80	3,400
1.70	190	2.80	675	3.90	1,480	6.00	3,640
1.80	223	2.90	740	4.00	1,570	6.20	3,880
1.90	258	3.00	810	4.20	1,750	6.40	4,120
2.00	295	3.10	880	4.40	1,930	6.60	4,360

The above table is applicable only for open-channel conditions. It is based upon 38 discharge measurements made during 1902, 1903, and 1904. It is well defined between gage heights 1.25 and 6 feet. The table has been extended beyond these limits.

The table supersedes those published in 1902 and 1903. Above 3 feet it has not been changed.

Estimated monthly discharge of St. Mary River near St. Mary, Mont., 1902–1904.

[Drainage area, 177 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January [a]	----------	----------	110	6,764	0.62	0.71
February [a]	----------	----------	120	6,664	.68	.71
March [a]	----------	----------	100	6,149	.56	.65
April [b]	223	120	146	8,688	.82	.91
May	4,000	190	1,729	106,312	9.77	11.26
June	3,760	950	1,862	110,796	10.52	11.74
July	4,360	1,160	2,164	133,059	12.23	14.10
August	1,160	565	785	48,267	4.44	5.12
September	515	258	342	20,350	1.93	2.15
October	258	190	221	13,589	1.25	1.44
November	190	127	156	9,282	.88	.98
December [c]	----------	----------	130	7,993	.73	.84
The year	----------	----------	655	477,913	3.70	50.61
1903.						
January [d]	158	72	93	5,718	.53	.61
February [d]	72	72	72	3,999	.41	.43
March [d]	72	50	57	3,505	.32	.37
April	223	72	129	7,676	.73	.81
May	2,110	223	743	45,685	4.20	4.84
June	3,640	2,110	3,154	187,676	17.82	19.89
July	3,280	1,160	1,832	112,645	10.35	11.93
August	1,160	675	860	52,879	4.86	5.60
September	1,160	465	643	38,261	3.63	4.05
October	1,090	465	646	39,721	3.65	4.20
November	465	295	379	22,552	2.14	2.39
December [e]	335	295	305	18,753	1.72	1.98
The year	3,640	50	743	539,070	4.20	57.10
1904.						
January [f]	----------	----------	120	7,379	.68	.78
February [f]	----------	----------	80	4,602	.45	.49

[a] Estimated by C. C. Babb.
[b] April 1-8, estimated by C. C. Babb.
[c] Frozen December 7 to 25, 1902. Mean estimated by C C. Babb.
[d] Probable ice conditions during January, February, and March. Rating table has been applied as for open channel.
[e] December 11 to 31, 1903, estimated by C. C. Babb.
[f] Frozen January 1 to 10, January 20 to April 2, and December 22 to 31. Means for January, February, March, and December estimated by C. C. Babb

Estimated monthly discharge of St. Mary River near St. Mary, Mont., 1902–1904—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1904.						
March [a]	.....	.....	80	4,919	.45	.52
April [a]	740	20	216	12,853	1.22	1.36
May	2,110	810	1,220	75,015	6.89	7.94
June	2,390	1,750	2,021	120,258	11.42	12.74
July	1,930	810	1,456	89,526	8.23	9.49
August	810	420	689	42,365	3.89	4.48
September	620	258	362	21,541	2.05	2.29
October	258	127	205	12,605	1.16	1.34
November	127	70	91	5,415	.51	.57
December [a]	72	50	51	3,136	.29	.33
The year	.....	.....	549	399,614	3.10	42.23

[a] Frozen January 1 to 10, January 20 to April 2, and December 22 to 31. Means for January, February, March, and December estimated by C. C. Babb.

ST. MARY RIVER NEAR CARDSTON, ALBERTA, N. W. T.

This station was established September 4, 1902, by C. T. Prall, at the ranch of L. C. Shaw, about 1,000 feet from the house. It is one-fourth of a mile north of the boundary line between the United States and Canada, and 17 miles south of Cardston, Alberta. The chain gage is located at the crossing near L. C. Shaw's house, about 1,200 feet above the cable. The first gage established here had a chain length of 11.40 feet. It was replaced in June, 1903, by the present gage, which has a chain length of 10.75 feet from the end of the weight to the marker, but the same gage datum. It is fastened to a tree and post on the bank. The marker is the outside edge of the ring at the end of the chain. The gage is read once each day by Vernon Shaw. Discharge measurements are made by means of a cable, car, and tagged wire. The initial point for soundings is the zero of the tagged wire on the left bank. The channel is straight for 300 feet above and 150 feet below the station. The right bank is high and not liable to overflow. The left bank is sloping and is liable to overflow at very high water. The bed of the stream is of sand and gravel and is not liable to scour. There is but one channel, and the current is swift near the right bank. Bench mark No. 1 is a 60-penny spike driven in a cottonwood tree located directly back of the rod. Its elevation is 12.92 feet above the zero of the gage. Bench mark No. 2 is a 60-penny spike driven in a post 1 foot in diameter and 2 feet high.

The post is set in the ground 92 feet northwest of the gage rod. Its elevation is 17.56 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of St. Mary River near Cardston, Alberta, in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec. feet.*
May 11	F. M. Brown	130	270	4.19	4.76	1,131
May 11	do	130	286	3.79	4.76	1,085
May 11	do	130	286	3.93	4.76	1,125
June 5	C. T. Prall	173	[a] 680	8.75	7.05	5,953
June 23	do	170	[a] 590	7.40	6.55	4,406
August 3	do	141	407	4.25	5.20	1,730
October 5	do	135	351	3.77	4.80	1,325
1904.						
May 10	L. R. Stockman	132	326	4.10	4.88	1,337
June 9	W. B. Freeman	161	517	6.36	6.02	3,288
July 12	Robert Follansbee	153	427	5.78	5.60	2,468
July 30	W. B. Freeman	135	318	3.81	4.82	1,213
September 3	do	123	232	2.62	4.03	608
November 19	L. R. Stockman	95	119	.80	2.45	96

[a] Recomputed, using standard section.

Mean daily gage height, in feet, of St. Mary River near Cardston, Alberta, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.[a]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.25	3.30	.....	.....	5.20	5.90	5.60	4.70	4.10	3.35	2.80	2.75
2	3.25	3.35	.....	.....	5.25	5.90	5.65	4.70	4.05	3.35	2.80	2.75
3	3.25	3.35	.....	.....	5.20	5.90	5.65	4.70	4.00	3.35	2.80	2.75
4	3.40	3.35	.....	.....	5.20	5.90	5.60	4.65	4.00	3.40	2.75	2.90
5	3.30	4.90	.....	[b] 6.15	5.05	5.90	5.60	4.65	4.00	3.40	2.70	2.90
6	3.15	5.20	.....	5.95	5.00	6.00	5.60	4.65	3.95	3.40	2.65	2.80
7	3.10	5.25	.....	5.50	5.00	6.15	5.60	4.70	3.90	3.40	2.60	2.80
8	3.10	5.10	.....	5.90	4.95	6.10	5.70	4.70	3.90	3.35	2.60	2.80
9	3.10	5.10	.....	6.15	4.90	5.95	5.65	4.75	3.90	3.35	2.65	3.00
10	3.25	5.45	.....	5.05	4.80	5.90	5.60	4.70	3.80	3.30	2.65	3.00
11	3.25	5.20	.....	4.20	4.90	5.85	5.55	4.65	3.80	3.30	2.60	3.10
12	3.25	5.30	.....	4.05	4.95	5.75	5.55	4.60	3.80	3.25	2.60	3.25
13	3.35	5.40	.....	4.05	4.90	5.60	5.40	4.50	3.80	3.25	2.60	3.00
14	3.25	5.40	.....	4.10	4.95	5.55	5.40	4.50	3.65	3.20	2.60	2.85
15	3.25	5.40	.....	4.10	5.00	5.55	5.35	4.45	3.65	3.15	2.60	2.90

[a] River frozen from January 18 to April 5. Readings to top of ice January 18 to February 22.
[b] Water running on ice April 5 to 11. Ice went out April 11.

Mean daily gage height, in feet, of St. Mary River near Cardston, Alberta, for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16	3.20	5.40	.....	4.00	5.05	5.70	5.35	4.45	3.65	3.10	2.60	2.90
17	3.20	5.40	.....	4.05	5.15	5.90	5.25	4.40	3.65	3.10	2.60	2.95
18	3.00	5.40	.....	4.10	5.25	6.05	5.15	4.40	3.55	3.10	2.60	(a)
19	3.00	5.40	.....	4.15	5.40	6.05	5.05	4.50	3.55	3.10	2.60	3.00
20	3.00	5.35	.....	4.30	5.45	6.00	4.95	4.50	3.50	3.05	2.60	3.00
21	3.05	5.35	.....	4.40	5.55	5.95	4.90	4.50	3.50	3.00	2.75	3.10
22	3.10	.....	.....	4.45	5.90	5.90	4.85	4.45	3.50	3.00	2.75	3.30
23	3.20	.....	.....	4.45	6.00	5.90	4.85	4.40	3.45	2.95	2.80	3.60
24	3.20	.....	.....	4.50	6.05	5.75	4.85	4.20	3.55	2.90	2.80	3.60
25	3.20	.....	.....	4.50	6.00	5.70	4.85	4.20	3.50	2.90	2.80	4.10
26	3.20	.....	.....	4.60	5.80	5.55	4.85	4.10	3.50	2.85	2.80	4.10
27	3.15	.....	.....	4.70	5.70	5.50	4.85	4.00	3.45	2.85	2.80	4.10
28	3.15	.....	.....	4.90	5.60	5.50	4.80	4.05	3.45	2.85	2.80	4.05
29	3.25	.....	.....	5.00	5.70	5.45	4.80	4.10	3.40	2.85	2.80	4.05
30	3.25	.....	.....	5.05	5.75	5.50	4.75	4.00	3.40	2.85	2.80	4.15
31	3.25	.....	.....	.....	5.85	.....	4.75	4.10	.....	2.85	.....	4.45

(a) Ice cut for readings. River completely frozen for remainder of month.

Rating table for St. Mary River near Cardston, Alberta, from September 13, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	100	3.40	288	4.30	785	5.40	2,055
2.60	109	3.50	325	4.40	870	5.60	2,385
2.70	121	3.60	365	4.50	960	5.80	2,755
2.80	136	3.70	410	4.60	1,055	6.00	3,165
2.90	153	3.80	460	4.70	1,155	6.20	3,605
3.00	174	3.90	515	4.80	1,260	6.40	4,075
3.10	198	4.00	575	4.90	1,370	6.60	4,585
3.20	225	4.10	640	5.00	1,490	6.80	5,135
3.30	255	4.20	710	5.20	1,755	7.00	5,725

The above table is applicable only for open-channel conditions. It is based upon 14 discharge measurements made during 1902, 1903, and 1904. It is well defined between gage heights 2.45 feet and 7.05 feet. The table supersedes all previous ones published.

Estimated monthly discharge of St. Mary River near Cardston, Alberta, 1902–1904.

[Drainage area, 452 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
September	747	198	604	35,940	1.34	1.50
October	608	306	477	29,330	1.06	1.22
November	410	174	342	20,350	.76	.85
December	1,755	255	1,092	67,144	2.42	2.79
The period				152,764		
1903.						
January [a]	1,105	575	855	52,572	1.89	2.18
February [a]	1,155	410	913	50,705	2.02	2.10
March [a]	2,755	827	1,269	78,028	2.81	3.24
April	2,565	365	1,068	63,550	2.36	2.63
May	3,060	870	1,720	105,759	3.81	4.39
June	6,175	4,075	5,200	309,421	11.50	12.82
July	4,855	1,900	2,924	179,790	6.47	7.46
August	1,900	1,105	1,404	86,329	3.11	3.59
September	2,300	710	1,109	65,990	2.45	2.73
October	1,687	575	917	56,384	2.03	2.34
November	870	365	535	31,835	1.18	1.32
December	675	288	438	26,931	.97	1.12
The year	6,175	288	1,529	1,107,294	3.38	45.92
1904.						
January [b]	288	174	224	13,773	.50	.58
February [c]			200	11,504	.44	.47
March [c]			200	12,298	.44	.51
April [d]			935	55,636	2.07	2.31
May	3,273	1,260	2,022	124,328	4.47	5.15
June	3,493	2,135	2,794	166,255	6.18	6.90
July	2,565	1,208	1,860	114,367	4.12	4.75
August	1,208	575	931	57,245	2.06	2.37
September	640	288	420	24,992	.93	1.04
October	288	144	213	13,097	.47	.54
November [c]	136	109	122	7,260	.27	.30
December [c]	240	128	157	9,654	.35	.40
The year			840	610,409	1.86	25.32

[a] Probable ice condition January, February, and March. Rating table applied as for open channel.
[b] River frozen January 18 to 31, table applied as for open channel.
[c] Mean for month estimated by Mr. C. C. Babb.
[d] Ice gorge April 5 to 10. Mean computed from April 11 to 30 is assumed as mean for entire month.

SWIFTCURRENT CREEK NEAR ST. MARY, MONT.

This station was originally established April 8, 1902, by J. S. Baker, and was located one-half mile northwest of Henkel's ranch and 36 miles northwest of Browning, Mont. The nearest post-office is Wetzel. Henkel's ranch is reached by regular stage from Wetzel, Mont. The channel is straight for 500 feet above and 200 feet below the station. The right bank is low and liable to overflow; the left bank is high and rocky. The bed of the stream is rocky. The station as originally established by J. S. Baker was washed away by the high water in June, 1902, and was reestablished July 30, 1902, by W. W. Schlecht. The original gage was placed on the right bank of the stream. The new gage was located 1,800 feet above the first gage and on the same bank of the stream. The gage was again moved on September 27, 1902, by C. T. Prall, and located about 900 feet above the former station, as the second location was directly above a dam. The length from the pointer to the bottom of the weight was 14.60 feet. The distance from the zero of the rod to the outside of the pulley was 2.15 feet. This gage was washed out about June 10, 1903, and replaced June 17 in practically its original position by a gage having the same length of wire and the same position of pulley with reference to the scale zero as the former one. Settlement of the gage made it necessary to change the chain length, November 18, to 14.65 feet. Chain length for 1905 is 14.57. Discharge measurements are made by means of a cable, car, tagged wire, and stay wire. At low water measurements are made by wading. The initial point for soundings was formerly on the left bank. Since September 2, 1904, it is located at a nail in the top of the upstream arm of the cable shears on the right bank. Bench mark No. 1 is a point chipped on a large bowlder 32.4 feet south of the gage. Its elevation is 12.52 feet above the zero of the gage. Bench mark No. 2 is the head of a 20-penny wire nail driven in a cottonwood tree 64.4 feet east of the gage. Its elevation is 12.86 feet above the zero of the gage. The gage is read once each day by Henry Henkel.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Swiftcurrent Creek near St. Mary, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 9	L. R. Stockman	66	108	3.70	3.10	400
June 8	W. B. Freeman	72	206	6.26	4.51	1,290
July 12	Robert Follansbee	65	145	5.03	3.66	730
July 29	W. B. Freeman	67	106	3.65	3.07	387
September 2 [a]	do	50	58	3.47	2.45	201
November 18 [b]	L. R. Stockman	11	8	4.40	1.80	36

[a] Measured from new cable station established September 2, 1904.
[b] Measured 750 feet below cable.

Mean daily gage height, in feet, of Swiftcurrent Creek near St. Mary, Mont., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					3.60	4.15	3.55	2.95	2.65	2.05	1.85	1.60
2					3.60	4.05	3.65	2.95	2.55	2.05	1.85	1.60
3					3.50	3.95	3.75	2.95	2.55	2.05	1.75	1.50
4					3.40	3.85	3.65	2.95	2.45	2.15	1.75	1.50
5				2.00	3.40	4.05	3.55	2.95	2.45	2.15	1.65	1.60
6				2.00	3.30	4.45	3.55	2.95	2.45	2.05	1.65	1.80
7				2.10	3.30	4.65	3.55	2.95	2.45	2.05	1.65	1.80
8				2.30	3.20	4.55	3.65	2.95	2.45	2.05	1.65	1.80
9				2.40	3.20	4.45	3.65	2.95	2.35	1.95	1.65	1.80
10				2.40	3.20	4.15	3.65	2.85	2.35	1.95	1.65	1.80
11				2.40	3.20	3.85	3.55	2.85	2.35	1.95	1.65	1.80
12	1.90			2.60	3.20	3.85	3.55	2.85	2.35	1.95	1.65	1.70
13	1.90			2.70	3.10	3.65	3.45	2.85	2.35	1.95	1.65	1.70
14	1.70			2.70	3.10	3.55	3.45	2.85	2.15	1.95	1.65	1.70
15	1.60			2.80	3.20	3.65	3.35	2.75	2.15	1.95	1.75	1.70
16	1.60			2.80	3.50	3.75	3.25	2.75	2.15	1.95	1.75	1.70
17	1.60			2.80	3.50	3.95	3.15	2.75	2.15	1.95	1.75	1.70
18	1.50			2.80	3.60	3.95	3.15	2.75	2.15	1.95	1.75	1.70
19	1.50			2.70	3.80	4.05	3.15	2.65	2.15	1.95	1.70	1.70
20				2.70	3.80	4.15	3.15	2.95	2.15	1.95	1.80	1.70
21				2.80	3.90	4.05	3.05	2.95	2.15	1.95	1.90	1.70
22				2.80	4.20	4.05	3.05	2.95	2.15	1.85	2.10	[b]
23				2.90	4.60	3.95	3.05	2.85	2.15	1.85	2.10	
24				2.90	4.20	3.85	3.05	2.85	2.05	1.75	2.10	
25				3.00	4.00	3.65	3.05	2.75	2.05	1.65	2.00	
26				3.20	3.80	3.55	2.95	2.55	2.05	1.75	2.00	
27				3.40	3.80	3.35	2.95	2.45	2.05	1.85	1.80	
28				3.60	3.70	3.35	2.95	2.45	2.05	1.85	1.70	
29				3.60	3.80	3.45	2.95	2.45	2.05	1.85	1.70	
30				3.70	3.90	3.45	2.95	2.45	2.05	1.95	1.60	
31					4.00		2.95	2.55		1.95		

[a] River frozen January 1 to April 5, with exception of January 12 to 19, when gage was read.
[b] River frozen from December 22 to 31.

Rating table for Swiftcurrent Creek near St. Mary, Mont., from June 17,[a] 1903, to December 31, 1904, superseding the table of 1903.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.50	14	2.70	250	3.80	880	4.90	1,745
1.60	17	2.80	285	3.90	955	5.00	1,830
1.70	24	2.90	325	4.00	1,030	5.10	1,915
1.80	36	3.00	370	4.10	1,105	5.20	2,000
1.90	52	3.10	420	4.20	1,180	5.30	2,090
2.00	70	3.20	475	4.30	1,260	5.40	2,180
2.10	90	3.30	535	4.40	1,340	5.50	2,270
2.20	112	3.40	600	4.50	1,420	5.60	2,360
2.30	136	3.50	670	4.60	1,500	5.70	2,450
2.40	162	3.60	740	4.70	1,580	5.80	2,540
2.50	190	3.70	810	4.80	1,660	5.90	2,630
2.60	219						

[a] Also applicable from April 25 to June 16, 1903, after adding 0.3 foot to gage heights, as published in Water-Supply Paper No. 100.

The above table is applicable only for open-channel conditions. It is based upon 22 discharge measurements made during 1903 and 1904. All measurements made during 1903 and 1904 have been corrected to a uniform area, using the measurement of May 9, 1904, by L. R. Stockman, as standard. With these corrections a fairly well-defined curve is obtained.

Estimated monthly discharge of Swiftcurrent Creek near St. Mary, Mont., for 1903 and 1904.[a]

[Drainage area, 101 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
January[b]	67	45	50	3,074	0.50	0.58
February[b]	52	45	46	2,555	.46	.48
March[b]	78	45	50	3,074	.50	.58
April	325	40	100	5,950	.99	1.10
May	1,180	162	465	28,592	4.60	5.30
June[c]	2,630	1,180	1,885	112,165	18.66	20.82
July	1,105	420	708	43,532	7.01	8.08
August	475	325	389	23,918	3.85	4.44

[a] 1902 rating table applied from January 1 to April 24, 1903. 1904 rating table applied from April 25, 1903 to December 31, 1904, after adding 0.3 foot to gage heights April 25 to June 7, 1903.
[b] Probable ice conditions. Rating table applied as for open channel.
[c] June 8–16, estimated.

Estimated monthly discharge of Swiftcurrent Creek near St. Mary, Mont., for 1903 and 1904—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
September	1,340	190	421	25,052	4.17	4.65
October	535	190	277	17,033	2.74	3.16
November	740	112	256	15,233	2.53	2.82
December[a]	219	136	166	10,207	1.64	1.89
The year	2,630	40	401	290,385	3.97	53.90
1904.						
January[b]			50	3,074	.50	.58
February[b]			40	2,301	.40	.43
March[b]			40	2,460	.40	.46
April	810	60	280	16,661	2.77	3.09
May	1,500	420	749	46,054	7.42	8.55
June	1,540	568	972	57,838	9.62	10.73
July	845	348	553	34,003	5.48	6.32
August	348	176	290	17,831	2.87	3.31
September	234	80	128	7,616	1.27	1.42
October	101	20	62	3,812	.61	.70
November[b]	90	17	36	2,142	.36	.40
December[b]	36	17	23	1,414	.23	.26
The year			269	195,206	2.66	36.25

[a] December 11–31, estimated.
[b] Means supplied by C. C. Babb. River frozen, with the exception of January 12 to 19, and November 1 to 19.

KENNEDY CREEK NEAR WETZEL, MONT.

This station was established October 17, 1903, by C. T. Prall. It is located 50 feet above the road from Altyn, Mont., to Cardston, Alberta. It is 35 miles northwest of Browning, Mont., and 20 miles from Wetzel, Mont., and about 5 miles north of the St. Mary dam site. The station is at the mouth of the canyon and about 1 mile above the mouth of Kennedy Creek. The horizontal wire gage is bolted to a tree and post on the bank of the river. The length of the wire from the end of the weight to the marker is 8.45 feet.

Discharge measurements are made by means of a cable, car, tagged wire, and stay wire. The initial point for soundings is the zero of the tagged wire on the left bank. The channel is straight for 200 feet above and 100 feet below the station. The current is very rapid at

high stages and moderate at low stages. The right bank is rocky and may overflow at extreme high water. The left bank is high and rocky and not liable to overflow. The bed of the stream is composed of bowlders and gravel, and is probably subject to some change at high floods. Bench mark No. 1 is a chipped point on a large bowlder at the strut near the north end of the cable. Its elevation is 12.88 feet above gage datum. Bench mark No. 2 is a 60-penny spike in a cottonwood tree 90 feet north of the gage. Its elevation is 10.49 feet above gage datum. No daily gage heights were read at this station, as it was impossible to procure a reader.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Kennedy Creek near Wetzel, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per. sec.*	*Feet.*	*Sec. feet.*
May 9	L. R. Stockman	51	58	2.49	6.13	145
June 8	W. B. Freeman	59	92	3.66	6.63	337
July 12	Robert Follansbee	59	81	2.04	6.40	165
July 30	W. B. Freeman	49	46	1.78	6.03	82
September 3	do	46	39	1.23	5.87	48
November 18	L. R. Stockman	37	27	.96	5.61	26

MOUSE RIVER NEAR FOXHOLM, N. DAK.

This station was established June 22, 1904, by E. F. Chandler, and is located at the highway bridge 3½ miles northeast of Foxholm, N. Dak., a flag station on the Minneapolis, St. Paul and Sault Ste. Marie Railway. A plain, vertical, staff gage is spiked to the downstream one of a row of piles that supports the bridge near the left bank. It is read once each day by H. Heinen. Discharge measurements are made from the downstream side of the single-span bridge to which the gage is attached. The initial point for soundings is the left end of the downstream hand rail. The channel is straight for about 300 feet above and 500 feet below the station and the current is sluggish. The right bank is covered with some brush and overflows only at extreme high water and only for a short distance. The left bank is a clean meadow. It overflows slightly during the ordinary spring floods, and in extreme floods overflows to a depth of several feet for a distance of nearly a half mile. The bed of the stream is composed of silt and mud and is not shifting. There is but one channel at ordinary stages, which during higher stages is broken by two rows of piles near each end of the bridge. The bench mark is two 12-penny nails driven into the upstream face of the pile to which the gage is

attached. Its elevation is 4.92 feet above the zero of the gage. The elevation of the zero of the gage, as determined by hand level from a Reclamation Service stake, is about 1,572 feet above sea level.

The observations at this station during 1904 have been made under the direction of E. Johnson, Jr., district hydrographer.

Discharge measurements of Mouse River near Foxholm, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 22	E. F. Chandler	66	313	1.46	4.97	459
July 14	R. Richards	63	203	1.06	3.26	215
August 13	do	63	145	.54	2.28	79
September 17	E. F. Chandler	62	142	.45	2.38	64

Mean daily gage height, in feet, of Mouse River near Foxholm, N. Dak., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		4.00	2.40	2.35	2.40	2.30
2		3.90	2.40	2.35	2.40	2.40
3		4.05	2.40	2.40	2.40	2.30
4		4.45	2.40	2.40	2.40	2.40
5		4.25	2.30	2.40	2.40	2.40
6		3.90	2.20	2.45	2.40	2.40
7		3.55	2.20	2.45	2.40	2.40
8		3.50	2.20	2.50	2.40	2.30
9		3.50	2.20	2.50	2.40	2.30
10		3.20	2.20	2.50	2.35	2.40
11		2.80	2.20	2.50	2.35	2.40
12		3.50	2.20	2.50	2.40	2.40
13		3.50	2.20	2.45	2.40	2.40
14		3.30	2.30	2.40	2.40	2.40
15		3.30	2.30	2.40	2.40	2.30
16		2.90	2.30	2.35	2.40	2.20
17		2.90	2.30	2.35	2.40	2.40
18		2.70	2.30	2.30	2.40	2.40
19		2.70	2.30	2.30	2.40	2.40
20		3.20	2.30	2.30	2.40	(a)
21		3.20	2.30	2.30	2.45	(a)
22		2.90	2.30	2.25	2.45	(a)
23	4.90	2.80	2.30	2.25	2.40	(a)
24	4.80	2.90	2.30	2.22	2.40	(a)
25	4.60	2.80	2.30	2.25	2.40	(a)
26	4.50	2.60	2.30	2.25	2.30	(a)
27	4.40	2.60	2.30	2.30	2.30	(a)
28	4.35	2.60	2.30	2.30	2.40	(a)
29	4.30	2.50	2.30	2.35	2.40	(a)
30	4.05	2.40	2.30	2.40	2.40	(a)
31		2.40	2.35		2.40	(a)

a River frozen from November 20 to December 31.

MOUSE RIVER AT MINOT, N. DAK.

This station was established May 5, 1903, by F. E. Weymouth. It is located at the footbridge, 150 feet northwest of the Great Northern Railway roundhouse at Minot, N. Dak. The gage is a vertical 1 by 6 inch board, 20 feet long, nailed to a pile of the center pier of the bridge on the downstream side. It is read once each day by H. E. Wheeler. Discharge measurements are made from the downstream side of the bridge, at which the gage is located. The bridge makes an angle of 15° with the normal to the direction of the current, which has to be taken into account in computing discharge measurements. The initial point for soundings is the zero mark on the downstream guard rail at the electric-light pole on the right bank. The channel is straight for 100 feet above and below the station. The current has a moderate velocity. Both banks are high, covered with trees and shrubs, and will not overflow. The bed of the stream is composed of sand and is fairly constant. There are some snags and brush in the bottom of the channel. Bench mark No. 1 is the top of the hydrant at the corner of the street, about 150 feet north of the bridge. Its elevation is 21.83 feet above the zero of the gage. Bench mark No. 2 is the top of the hydrant one block west of bench mark No. 1. This elevation is 21.85 feet above the zero of the gage. Bench mark No. 3 is the top of the rail of the side track at the southwest corner of the roundhouse. Its elevation is 24.18 feet above the zero of the gage. The top of the rail of the main track of the Great Northern Railway station has an elevation of 24.49 feet above the zero of the gage. As determined by connection with railroad levels, the zero of the gage has an elevation of 1,540 feet above sea level. The drainage area of Mouse River at this station is 8,400 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Mouse River near Minot, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 17	E. F. Chandler	170	1,880	1.65	17.92	3,107
April 30	do	1,668	4,391	1.83	20.48	8,056
May 31	R. Richards	118	1,267	1.44	14.68	1,824
June 22	E. F. Chandler	88	400	1.74	6.69	698
June 24	do	87	373	1.54	6.32	577
July 13	R. Richards	83	291	.96	5.16	279
July 14	do	83	299	1.04	5.29	312
August 12	do	77	220	.46	4.40	102
September 18	E. F. Chandler	74	220	.40	4.30	88

Mean daily gage height, in feet, of Mouse River near Minot, N. Dak., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	20.3	13.9	5.8	4.6	4.4	4.2	4.2
2	.....	20.2	11.7	5.7	4.6	4.3	4.2	4.2
3	6.0	20.1	10.5	5.6	4.5	4.3	4.2	4.2
4	7.0	20.0	9.7	5.6	4.5	4.3	4.25	4.15
5	9.3	19.9	9.5	5.5	4.5	4.3	4.3	4.15
6	10.6	19.9	9.2	5.3	4.5	4.3	4.25	4.15
7	11.3	19.9	9.0	5.1	4.5	4.3	4.25	4.15
8	12.8	19.9	8.8	5.1	4.4	4.3	4.25	4.15
9	13.8	19.9	8.7	5.1	4.4	4.3	4.25	4.15
10	14.2	19.9	8.6	5.0	4.4	4.3	4.25	4.15
11	14.8	19.8	8.5	5.0	4.4	4.3	4.25	4.15
12	15.7	19.8	8.4	5.0	4.4	4.3	4.25	4.15
13	16.0	19.8	8.1	5.0	4.4	4.3	4.2	4.1
14	16.4	19.7	8.0	5.0	4.4	4.3	4.2	4.1
15	16.8	19.4	7.8	5.0	4.4	4.3	4.2	4.1
16	17.2	19.2	7.7	5.0	4.4	4.3	4.2	4.1
17	18.1	19.0	7.5	5.0	4.4	4.3	4.2	4.1
18	18.6	18.9	7.2	5.0	4.4	4.3	4.25	4.3
19	19.0	18.7	7.0	5.0	4.4	4.3	4.25	4.3
20	[a]21.9	18.6	7.0	5.0	4.4	4.25	4.2	4.25
21	21.8	18.4	6.9	5.0	4.4	4.25	4.2	4.25
22	21.7	18.2	6.7	5.0	4.4	4.25	4.2	4.25
23	21.5	18.0	6.6	5.0	4.4	4.2	4.2	4.25
24	21.3	17.9	6.4	5.0	4.4	4.2	4.2	4.2
25	21.0	17.5	6.2	5.0	4.4	4.2	4.2	4.2
26	20.9	17.1	6.1	4.9	4.4	4.2	4.2	[b]
27	20.8	16.8	6.0	4.9	4.4	4.2	4.2	[b]
28	20.7	16.4	6.0	4.8	4.4	4.2	4.2	[b]
29	20.6	16.2	5.9	4.7	4.4	4.2	4.2	[b]
30	20.6	15.0	5.8	4.7	4.4	4.2	4.2	[b]
31	.....	14.5	.....	4.6	4.4	.....	4.2	.....

[a] From April 20 to 30 the river rose above the gage. The heights are estimated from observer's report and high-water marks.
[b] Frozen.

DES LACS RIVER AT FOXHOLM, N. DAK.

This station was established June 23, 1904, by E. F. Chandler. It is located at the highway bridge at Foxholm, a station on the Minneapolis, St. Paul and Sault Ste. Marie Railway. A plain staff gage, graduated to feet and tenths, is nailed to the downstream side of the first pier from the left bank. This pier is composed of a row of piles parallel to the bank of the stream. The gage is read once each day by L. S. Alden. Discharge measurements are made from the downstream side of the highway bridge to which the gage is attached. The initial point for soundings is the right end of the downstream hand rail. The channel is straight for about 75 feet above and 25 feet below the station. There is but one channel at ordinary stages. During high water the channel is divided by the piling piers of the bridge. The current is sluggish at low stages. The right bank is high, covered with brush, and does not overflow. The left bank is covered with brush and does not overflow except in high floods, when the water may pass across a neck a few rods east of the bridge. The bed

of the stream is composed of silt and mud, and is slightly shifting. The bench mark is a group of four spikes driven into the pile beside the gage rod. Its elevation is 10.00 feet above the zero of the gage, as obtained by hand level from the railroad, is 1,633 feet above sea level.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Des Lacs River at Foxholm, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 23	E. F. Chandler	18	51	0.80	3.80	41
July 13	R. Richards	18	41	.58	3.12	24
August 12	do	18	30	.32	2.45	9.6
September 17 [a]	E. F. Chandler	14	4.5	1.10	2.22	5.0
September 17	do	18	23	.28	2.22	6.2

[a] Measurements by wading.

Mean daily gage height, in feet, of Des Lacs River at Foxholm, N. Dak., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.[a]	Dec.[a]
1		3.50	2.72	2.00	2.28	2.10	
2		3.50	2.70	2.00	2.28	2.15	
3		3.45	2.70	2.00	2.29	2.18	
4		3.40	2.70	2.10	2.31	2.20	
5		3.40	2.68	2.10	2.33	2.22	
6		3.35	2.68	2.10	2.35	2.25	
7		3.30	2.55	2.15	2.35	2.25	
8		3.25	2.54	2.19	2.38	2.23	
9		3.25	2.52	2.19	2.40	2.21	
10		3.20	2.50	2.18	2.40	2.20	[b]2.35
11		3.20	2.48	2.18	2.40	2.20	
12		3.15	2.45	2.15	2.40	2.00	
13		3.15	2.42	2.20	2.40	2.00	
14		3.25	2.40	2.20	2.40	1.98	
15		3.45	2.35	2.20	2.40	1.98	
16		3.20	2.32	2.22	2.40	1.95	
17		3.15	2.30	2.21	2.40	1.95	[c]2.30
18		3.10	2.28	2.21	2.40	1.92	
19		3.05	2.25	2.21	2.40	1.90	
20		3.00	2.25	2.20	2.40	1.90	
21		2.97	2.27	2.20	2.40	1.90	
22		2.95	2.25	2.20	2.40	1.90	
23	3.80	2.90	2.25	2.20	2.42	1.90	
24	3.80	2.87	2.25	2.21	2.40	1.90	
25	3.75	2.84	2.25	2.21	2.35	(d)	[e]2.30
26	3.75	2.80	2.22	2.22	2.30	1.90	
27	3.70	2.80	2.20	2.25	2.25		
28	3.65	2.75	2.20	2.25	2.15		
29	3.60	2.75	2.20	2.26	2.10		
30	3.55	2.75	2.00	2.28	2.05		
31		2.73	2.00		2.05		[f]2.30

[a] Gage heights read to water surface during frozen period.
[b] Ice 4 inches thick.
[c] Ice 6 inches thick.
[d] River frozen over.
[e] Ice 10 inches thick.
[f] Ice 13 inches thick.

Rating table for Des Lacs River at Foxholm, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.90	2	2.40	9	2.90	19	3.40	29
2.00	3	2.50	11	3.00	21	3.50	32
2.10	4	2.60	13	3.10	23	3.60	35
2.20	5	2.70	15	3.20	25	3.70	38
2.30	7	2.80	17	3.30	27	3.80	41

The above table is applicable only for open-channel conditions. It is based upon 5 discharge measurements made during 1904. It is well defined between gage heights 2.2 feet and 3.8 feet.

Estimated monthly discharge of Des Lacs River at Foxholm, N. Dak., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
June 23–30	41	34	38.1	605
July	32	16	23.3	1,433
August	15.3	3	8.8	540
September	6.6	3	4.9	290
October	9	3.5	7.8	477
November 1–24	6	2	3.6	173

RED RIVER AT FARGO, N. DAK.

This station was established May 27, 1901, by C. M. Hall, and is located at the bridge connecting Front street, Fargo, N. Dak., and Main street, Moorhead, Minn. The gage consists of a 1 by 8 inch board, painted white, graduated to feet and tenths in black, and attached to the east side of the breakwater for the center pier of the bridge. The zero of the gage is 44.45 feet below the top of the plank walk of the bridge over the gage and is 860.9 feet above sea level, the elevation having been determined by leveling from the top of rail of Northern Pacific Railway station, Moorhead, Minn. The observer is H. R. Grasse, United States Weather Bureau, Moorhead, Minn. Discharge measurements were originally made from the bridge to which the gage is attached, but owing to unfavorable conditions for accurate measurement the measuring section was changed June 10, 1904, to the footbridge at the Fargo waterworks, one-half mile upstream from the gage, except at unusually high stages, when measurements are made from the Northern Pacific Railway bridge, 15 rods

below the gage. A movable timber and stay cable, enabling the meter to be held about 7 feet horizontally upstream from the footbridge, obviates the influence of the small piling piers. This equipment is stored in the pump house of the waterworks. The initial point at the footbridge is an electric-light pole on the right bank. The initial point at the railway bridge is the right end of the draw span. The channel is straight for about 100 feet above and 150 feet below the station, and the current is medium. The left bank is high and steep, while the right bank is low and subject to overflow at times of high water. The bed of the stream is composed of silt and mud and is fairly permanent. There is but one channel at all stages. The bench mark is a point on the extreme north end of the flat top of the concrete pier of the railway bridge at the initial point for soundings. Its elevation is 37.12 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Red River at Fargo, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 14[a]	E. F. Chandler	124	1,064	2.13	15.97	2,269
May 10[b]	do	107	638	1.87	10.59	1,193
May 10[c]	do	109	610	1.95	10.59	1,190
June 6[c]	do	95	493	1.88	10.18	925
June 10[c]	do	108	588	1.84	10.40	1,082
June 10[b]	E. C. Murphy	92	592	1.82	10.38	1,076
June 27[c]	E. F. Chandler and R. Richards.	128	1,114	2.37	14.38	2,642
July 6[c]	R. Richards	113	724	1.93	11.44	1,404
July 30[c]	do	101	429	1.50	8.88	643
October 17[c]	do	98	357	1.44	8.22	516

[a] Backwater due to ice jams. [b] Front Street Bridge.
[c] Regular station at waterworks bridge.

Mean daily gage height, in feet, of Red River at Fargo, N. Dak., for 1904.

Day.	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		11.3	12.0	9.8	13.7	8.8	7.7	8.0	8.1
2		11.0	11.2	9.8	13.0	8.7	7.8	8.0	8.1
3		11.3	10.8	9.8	12.5	8.6	7.8	8.1	8.1
4		11.5	10.5	10.0	12.0	8.6	8.0	8.2	8.1
5		11.7	10.5	10.1	11.6	8.5	8.2	8.2	8.0
6		11.7	10.4	10.1	11.3	8.5	8.3	8.2	8.0
7		11.9	10.4	10.1	11.1	8.5	8.3	8.2	8.0
8		12.4	10.4	10.1	11.1	8.5	8.3	8.2	8.0
9		11.7	10.5	10.2	10.8	8.4	8.3	8.2	8.0

[a] River frozen during March and December.

Mean daily gage height, in feet, of Red River at Fargo, N. Dak., for 1904—Continued.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
10	.....	11.8	10.6	10.5	10.7	8.4	8.2	8.2	8.0
11	.....	12.2	10.6	10.5	10.6	8.3	8.2	8.2	8.0
12	.....	12.9	10.6	10.5	10.7	8.3	8.2	8.3	8.0
13	.....	14.0	10.5	10.4	10.8	8.3	8.1	8.2	8.0
14	.....	15.8	10.6	10.3	10.8	8.3	8.1	8.2	8.0
15	8.6	17.8	10.6	10.1	10.6	8.3	8.0	8.2	8.0
16	8.6	19.0	10.1	10.0	10.5	8.3	8.0	8.2	8.0
17	8.6	19.7	10.0	9.9	10.4	8.3	8.0	8.3	8.0
18	8.6	20.5	9.9	9.8	10.2	8.3	8.0	8.3	8.0
19	8.6	21.2	9.8	9.7	10.0	8.3	8.0	8.3	8.0
20	8.6	21.3	9.7	9.7	9.9	8.2	8.0	8.2	8.0
21	8.6	20.9	9.7	9.6	9.9	8.2	8.0	8.2	8.0
22	8.7	20.2	9.7	9.5	9.5	8.1	8.0	8.2	8.0
23	8.7	19.5	9.7	9.5	9.4	8.1	8.0	8.2	8.0
24	9.3	18.5	9.7	10.5	9.2	8.0	8.0	8.2	8.0
25	9.5	17.7	9.8	11.5	9.0	8.0	8.0	8.3	8.0
26	9.5	16.7	9.8	13.3	9.0	8.0	8.0	8.3	8.0
27	9.5	16.0	9.8	14.5	9.0	7.9	7.9	8.2	7.7
28	9.5	15.0	9.8	14.8	8.9	7.8	7.9	8.2	7.4
29	9.5	13.7	9.9	14.8	8.9	7.8	7.9	8.2	7.0
30	10.3	12.8	9.9	14.4	8.8	7.7	7.9	8.1	7.2
31	10.9	.....	9.9	.....	8.8	7.7	.....	8.1	.....

Rating table for Red River at Fargo, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
7.00	231	8.40	536	9.80	907	11.40	1,422
7.10	252	8.50	560	9.90	936	11.60	1,496
7.20	273	8.60	585	10.00	966	11.80	1,572
7.30	294	8.70	610	10.10	996	12.00	1,650
7.40	315	8.80	636	10.20	1,026	12.20	1,730
7.50	336	8.90	662	10.30	1,057	12.40	1,811
7.60	357	9.00	688	10.40	1,088	12.60	1,893
7.70	378	9.10	714	10.50	1,119	12.80	1,976
7.80	400	9.20	741	10.60	1,151	13.00	2,060
7.90	422	9.30	768	10.70	1,183	14.00	2,480
8.00	444	9.40	795	10.80	1,215	15.00	2,920
8.10	466	9.50	822	10.90	1,248		
8.20	489	9.60	850	11.00	1,281		
8.30	512	9.70	878	11.20	1,350		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 7 feet and 11.5 feet. Above gage height 11.50 the extension of the curve is determined by a measurement at 14.4 feet gage height. Discharges applied to gage heights above 15 feet are approximate estimates.

Estimated monthly discharge of Red River at Fargo, N. Dak., for 1904.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	6,089	1,281	3,222	191,700	0.537	0.599
May	1,650	878	1,043	64,130	.174	.201
June	2,832	822	1,268	75,460	.211	.235
July	2,354	636	1,124	69,120	.187	.216
August	636	378	502	30,870	.084	.097
September	512	378	452	26,900	.075	.084
October	512	444	488	30,010	.081	.093
November	466	231	428	25,470	.071	.079
The period				513,700		

RED RIVER AT GRAND FORKS, N. DAK.

This station was established May 26, 1901, by C. M. Hall. It is located at the Northern Pacific Railway bridge at Grand Forks, N. Dak. The original gage is a vertical 1 by 8 inch board attached to the north end of the breakwater of the middle bridge pier. The zero of this gage was placed 5 feet below the zero of the United States Army engineers' gage, which is attached to the same breakwater. A standard chain gage has been established with the same datum as the vertical gage and is attached to the downstream side of the bridge. The length of the chain from the end of the weight to the marker is 50.44 feet. The gage is read once each day by Philip Hayes. Discharge measurements are made from the Great Northern Railway bridge, about one-fifth mile above the gage. The initial point for soundings is marked in red paint on the downstream guard rail at the left end of the left span. The channel is straight for 500 feet above and for 150 feet below the Great Northern Railway bridge. The current has a moderate velocity. The right bank is liable to overflow at high stages and is wooded. The left bank will overflow only at very high stages and for a short distance. The water at all stages will pass beneath the 4-span bridge and its trestle approaches. The bed of the stream is composed of sand and mud and is subject to some change. The water is usually heavily laden with sediment from Red Lake River, which enters one-half mile above the station. Bench mark No. 1 is the north corner of the iron plates of the turntable near the center of the middle pier of the Northern Pacific Railway bridge. The bench mark is on the north side, about 1 inch above the surface of the stone pier. Its elevation is 43.95 feet above gage datum. Bench mark No. 2 is a spike in a telegraph pole in the lumber yard southwest of the left end of the bridge, from which it is 200 feet distant. Its elevation is 48.50

feet above gage datum. The top of the pulley of the chain gage is 53.12 feet above gage datum. Gage datum is 45.58 feet above the city datum of Grand Forks and is 777.9 feet above sea level.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Red River at Grand Forks, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 12	R. Richards	665	11,560	1.81	35.74	20,970
April 25	E. F. Chandler	908	16,130	1.99	39.92	32,040
May 9	R. Richards	307	5,338	2.56	25.09	13,640
May 23	E. F. Chandler	207	2,814	2.95	17.10	8,292
June 9	E. C. Murphy	192	2,313	2.79	14.55	6,442
August 18	R. Richards	155	876	1.91	6.62	1,674
October 3	E. F. Chandler	150	868	1.74	6.48	1,510

Mean daily gage height, in feet, of Red River at Grand Forks, N. Dak., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	10.45	38.45	14.22	14.21	7.85	6.45	6.48	6.98	.....
2	.....	.....	.....	12.85	37.28	14.05	14.10	7.76	6.60	6.58	6.93	.....
3	.....	.....	.....	15.90	35.88	13.88	13.80	7.61	6.76	6.55	7.08	[a]6.40
4	.....	.....	.....	19.90	33.90	13.72	13.44	7.80	6.75	6.70	6.95	.....
5	.....	.....	.....	24.45	31.62	13.90	12.90	7.80	6.80	6.78	6.90	.....
6	.....	.....	.....	28.55	29.25	13.92	12.38	7.58	6.82	6.91	6.88	.....
7	7.7	7.3	7.1	31.42	27.35	14.05	12.20	7.50	7.10	6.60	6.92	[a]6.40
8	.....	.....	.....	34.35	25.88	14.28	11.78	7.35	7.12	6.88	6.88	.....
9	.....	.....	.....	35.32	25.20	14.58	11.56	7.28	7.04	6.80	6.68	.....
10	.....	.....	.....	35.68	24.98	14.70	11.38	7.10	7.00	6.85	6.92	.....
11	.....	.....	.....	35.90	24.85	14.80	11.02	6.90	6.82	7.22	6.88	.....
12	.....	.....	.....	35.80	24.74	14.90	10.80	6.90	6.70	6.92	6.82	.....
13	.....	.....	.....	35.75	24.38	14.82	10.68	6.98	6.55	6.98	6.75	.....
14	7.5	7.2	7.4	35.90	23.78	14.72	10.46	6.89	6.69	7.10	6.62	[a]6.30
15	.....	.....	.....	[b]35.88	23.10	14.50	10.40	6.79	6.60	7.22	6.52	.....
16	.....	.....	.....	35.34	22.38	14.05	10.12	6.83	6.45	7.25	6.65	.....
17	.....	.....	.....	35.74	21.65	13.78	10.23	6.61	6.60	7.35	6.78	.....
18	.....	.....	.....	35.52	20.75	13.72	10.21	6.60	6.32	7.40	6.82	.....
19	.....	.....	.....	34.70	19.90	13.70	10.02	6.70	6.45	7.22	6.85	.....
20	.....	.....	.....	35.20	19.12	13.78	9.93	6.52	6.32	7.25	6.75	.....
21	7.8	7.0	7.65	35.92	18.42	13.70	9.70	6.50	6.61	7.58	6.60	[a]6.40
22	.....	.....	.....	36.58	17.78	13.32	9.46	6.41	6.58	7.32	6.78	.....
23	.....	.....	.....	37.70	17.05	13.10	9.28	6.49	6.38	7.48	6.60	.....
24	.....	.....	.....	38.88	16.50	12.82	9.08	6.59	6.38	7.28	6.78	.....
25	.....	.....	.....	39.90	16.22	12.55	8.90	6.54	6.48	7.48	6.72	.....
26	.....	.....	.....	40.50	15.85	12.44	8.70	6.42	6.38	7.32	6.68	.....
27	.....	.....	.....	40.62	15.60	12.42	8.55	6.38	6.45	7.26	7.20	.....
28	.....	.....	.....	40.40	15.38	13.05	8.36	6.39	6.50	7.05	(a)	.....
29	.....	6.95	.....	39.98	15.05	13.84	8.20	6.15	6.52	7.42	(a)	.....
30	.....	.....	.....	39.38	14.78	14.19	8.40	6.05	6.48	7.15	6.50	.....
31	7.3	.....	9.75	.....	14.39	.....	8.08	6.29	.....	7.02	.....	[a]6.50

[a] River frozen at gage; readings to surface of water; ice 3.5 to 14 inches thick.
[b] Ice running April 15.

NOTE.—During January, February, and March gage read to surface of water; ice 26 inches thick.

Rating table for Red River at Grand Forks, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.00	1,300	8.20	2,470	10.80	4,010	17.00	8,290
6.10	1,350	8.30	2,525	11.00	4,130	17.50	8,665
6.20	1,400	8.40	2,580	11.20	4,260	18.00	9,040
6.30	1,450	8.50	2,635	11.40	4,390	18.50	9,420
6.40	1,500	8.60	2,690	11.60	4,520	19.00	9,820
6.50	1,550	8.70	2,750	11.80	4,650	19.50	10,220
6.60	1,600	8.80	2,810	12.00	4,780	20.00	10,620
6.70	1,650	8.90	2,870	12.20	4,910	21.00	11,440
6.80	1,700	9.00	2,930	12.40	5,040	22.00	12,290
6.90	1,755	9.10	2,990	12.60	5,170	23.00	13,140
7.00	1,810	9.20	3,050	12.80	5,300	24.00	14,020
7.10	1,865	9.30	3,110	13.00	5,430	25.00	14,920
7.20	1,920	9.40	3,170	13.20	5,560	26.00	15,870
7.30	1,975	9.50	3,230	13.40	5,700	27.00	16,840
7.40	2,030	9.60	3,290	13.60	5,840	28.00	17,840
7.50	2,085	9.70	3,350	13.80	5,980	29.00	18,880
7.60	2,140	9.80	3,410	14.00	6,120	30.00	19,960
7.70	2,195	9.90	3,470	14.50	6,470	31.00	21,080
7.80	2,250	10.00	3,530	15.00	6,820	32.00	22,240
7.90	2,305	10.20	3,650	15.50	7,170	33.00	23,440
8.00	2,360	10.40	3,770	16.00	7,540	34.00	24,650
8.10	2,415	10.60	3,890	16.50	7,915		

The above table is applicable only for open-channel conditions. It is based upon 16 discharge measurements made during 1903 and 1904. It is well defined between gage heights 5 feet and 18 feet. Above 18 feet a measurement at 39.92 feet determines the direction of the curve. The table has been extended beyond these limits. Above gage height 34 feet the rating curve is a tangent, the difference being 125 per tenth.

Estimated monthly discharge of Red River at Grand Forks, N. Dak., for 1904.

[Drainage area, 25,800 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April 15–30	32,920	25,520	29,200	926,700	1.13	0.673
May	30,210	6,393	13,720	843,600	.532	.613
June	6,750	5,053	6,020	358,200	.233	.260
July	6,267	2,404	3,914	240,700	.152	.175
August	2,278	1,325	1,758	108,100	.068	.078
September	1,876	1,460	1,613	95,980	.062	.069
October	2,074	1,540	1,854	114,000	.072	.083
November, 28 days	1,920	1,550	1,704	94,640	.066	.069
The period				2,782,000		

OTTER TAIL RIVER NEAR FERGUS FALLS, MINN.

This station was established May 9, 1904, by E. F. Chandler. It is located at Three-Mile Bridge, about 3½ miles northeast of Fergus Falls, Minn. The temporary gage is a 2 by 6 inch timber graduated by feet and tenths from 1 to 6.2 feet, and marked with brass-headed nails driven into the bank near the lower corner of the left abutment. Gravel covers the rod to the 2.2-foot mark. The gage is read once each day by H. G. Evensen, jr. Discharge measurements are made from the lower side of the single-span steel highway bridge at which the gage is placed. The initial point for soundings is the left end of the downstream hand rail. Ten-foot intervals are marked along the rail with brass-headed nails. The channel is straight for about 150 feet above and for 600 feet below the station. The current is medium at all stages. Both banks are high, wooded, and do not overflow. The bed of the stream is composed of clean gravel and small stones, and is probably permanent except after extreme floods. There is one channel at ordinary stages, and two possible at high water. The chief source of supply is Otter Tail Lake; therefore sudden fluctuations in river height are not to be expected. The bench mark is a nail driven into the stone wing wall of the left abutment, downstream side, about 4½ feet from the angle of the abutment and just behind the temporary gage. Its elevation is 5.56 feet above the zero of the gage.

The observations have been made during 1904 under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Otter Tail River near Fergus Falls, Minn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 9	E. F. Chandler	97	197	2.50	3.54	491
June 4	do	97	222	3.08	3.74	684
June 11	E. C. Murphy	97	221	2.93	3.70	647
July 23	R. Richards	97	187	2.48	3.34	464
August 20	do	98	163	2.14	3.07	348
September 26	E. F. Chandler	98	146	2.16	2.98	316

Mean daily gage height, in feet, of Otter Tail River near Fergus Falls, Minn., for 1904.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.65	3.8	3.3	3.05	3.0	3.05	.....
2	.....	3.65	3.75	3.25	3.1	3.0	3.05	.....
3	.....	3.75	3.75	3.25	3.1	3.0	3.05	.....
4	.....	3.8	3.7	3.25	3.1	3.0	3.05	.....
5	.....	3.85	3.7	3.25	3.1	3.0	3.05	.....
6	.....	3.85	3.65	3.25	3.1	3.0	3.05	.....
7	.....	3.8	3.6	3.25	3.05	3.0	3.05	.....
8	.....	3.8	3.55	3.25	3.05	3.0	3.0	.....
9	3.55	3.75	3.55	3.2	3.05	3.0	3.0	.....
10	3.55	3.7	3.55	3.2	3.05	3.0	3.0	.....
11	3.5	3.7	3.55	3.2	3.05	3.0	3.0	.....
12	3.45	3.7	3.5	3.15	3.05	3.0	3.0	.....
13	3.5	3.7	3.5	3.15	3.05	3.0	3.0	.....
14	3.55	3.75	3.5	3.15	3.0	3.0	3.0	.....
15	3.55	3.75	3.45	3.15	3.0	3.05	3.0	.....
16	3.55	3.75	3.4	3.15	3.0	3.05	3.0	.....
17	3.5	3.65	3.4	3.1	3.0	3.05	3.0	.....
18	3.5	3.65	3.5	3.1	3.0	3.05	3.0	.....
19	3.55	3.65	3.5	3.1	3.0	3.05	3.0	.....
20	3.55	3.6	3.45	3.1	3.0	3.05	3.0	.....
21	3.6	3.6	3.45	3.1	3.0	3.0	3.0	.....
22	3.65	3.6	3.4	3.1	3.0	3.0	3.0	(a)
23	3.65	4.2	3.35	3.1	3.0	3.0	3.05	.....
24	3.7	3.9	3.35	3.05	3.0	3.0	3.05	.....
25	3.7	3.85	3.35	3.05	3.0	3.0	3.05	.....
26	3.65	3.8	3.3	3.05	3.0	3.05	3.05	.....
27	3.65	3.8	3.3	3.05	3.0	3.05	3.05	.....
28	3.65	3.75	3.35	3.05	3.0	3.05	3.10	.....
29	3.65	3.8	3.35	3.05	3.0	3.05	(b)	.....
30	3.65	3.8	3.3	3.05	3.0	3.05	.....	.....
31	3.7	.....	3.3	3.05	.....	3.05	.....	.....

a Ice 16 inches thick December 22.

b River frozen over November 29.

Rating table for Otter Tail River near Fergus Falls, Minn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	320	3.40	456	3.70	650	4.00	905
3.10	350	3.50	500	3.80	735	4.10	990
3.20	383	3.60	568	3.90	820	4.20	1,075
3.30	418						

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1904. It is fairly well defined between gage heights 3.0 feet and 3.75 feet. The table has been extended above gage height 3.75 feet.

Estimated monthly discharge of Otter Tail River near Fergus Falls, Minn., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
May (9–31)	650	478	565	25,780
June	1,075	568	696	41,420
July	735	418	513	31,540
August	418	335	365	22,440
September	350	320	329	19,580
October	335	320	326	20,040
November (1–28)	350	320	328	18,220

SHEYENNE RIVER NEAR HAGGART, N. DAK.

This station was established March 22, 1902, by C. M. Hall. It is located near the way station of Haggart, on the Northern Pacific Railway, 5 miles west of Fargo, N. Dak., at a private wagon bridge about one-fourth of a mile north of the railroad. The gage is a vertical 1 by 6 inch board fastened to the piling pier at the middle of the bridge, divided into feet and tenths, and reads up to 17 feet. It is read once each day by John C. Haggart. Discharge measurements are made from the same bridge. The initial point for soundings is the end of the hand rail on the lower side of the bridge, right bank. The channel is straight for 30 feet above and 200 feet below the station and the current moderate. Both banks are steep and not liable to overflow except in unusual floods. There is a single channel at all stages and its bed is of clay and only slightly shifting.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Sheyenne River near Haggart, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-Feet.*
April 14	E. F. Chandler	76	824	1.44	15.45	1,186
May 10	do	79	957	1.84	17.08	1,763
June 6	do	49	207	2.01	7.14	415
June 10	E. C. Murphy	52	230	1.93	7.19	443
June 27	E. F. Chandler	50	189	1.83	6.32	348
July 30	R. Richards	46	98	1.78	4.41	175
October 17	do	46	94	1.14	4.19	107

Mean daily gage height, in feet, of Sheyenne River near Haggart, N. Dak., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	12.05	18.40	6.50	6.00	4.20	3.90	4.00	3.95	[a] 4.00
2	.....	12.40	18.40	6.50	5.90	4.40	4.20	3.90	3.80	4.00
3	.....	12.85	18.35	6.40	5.90	4.38	3.90	3.80	3.90	4.00
4	.....	12.85	18.30	6.50	5.80	4.30	3.90	3.90	3.95	.....
5	.....	13.05	18.20	6.60	5.70	4.10	3.30	4.10	3.90	.....
6	.....	12.90	18.15	7.30	5.70	4.00	3.90	4.10	3.90	.....
7	.....	12.50	18.05	7.20	5.60	4.00	3.90	3.90	3.90	.....
8	.....	11.90	17.70	6.90	5.50	3.88	3.90	3.80	3.80	.....
9	.....	12.45	17.25	6.90	5.40	3.90	3.80	4.50	3.85	.....
10	.....	12.85	16.85	7.50	5.20	4.10	3.60	4.60	3.80	.....
11	.....	13.15	15.40	7.60	5.10	4.05	3.00	4.30	3.90	.....
12	.....	14.00	13.25	8.50	5.50	3.98	3.70	4.10	4.00	.....
13	.....	[b] 15.10	11.75	8.50	5.30	3.92	4.00	3.90	4.10	.....
14	.....	15.70	10.65	9.00	5.40	3.95	3.90	3.80	3.90	.....
15	.....	16.00	10.15	9.00	5.40	3.75	4.15	4.00	4.00	.....
16	.....	15.50	9.65	8.90	5.50	3.82	3.95	3.90	3.90	.....
17	.....	15.85	9.15	8.70	5.50	3.98	4.00	3.90	4.10	.....
18	.....	16.80	8.80	8.10	5.40	3.95	3.90	3.90	4.00	.....
19	.....	17.75	8.40	7.80	5.70	3.85	3.80	3.85	3.90	.....
20	.....	18.10	8.15	6.30	5.50	3.90	3.60	3.90	4.00	.....
21	.....	18.15	7.90	6.50	5.30	3.95	3.90	3.90	4.10	.....
22	[c]	[b] 18.60	7.70	6.00	5.20	3.95	4.00	3.90	3.90	.....
23	.....	18.45	7.60	5.90	4.90	3.20	4.10	3.90	4.00	.....
24	6.00	18.40	7.45	6.20	4.70	3.90	4.00	3.85	3.90	.....
25	6.20	18.40	7.40	6.40	4.50	3.80	3.80	3.80	4.10	.....
26	[d] 6.30	18.40	7.30	6.30	4.70	3.60	3.90	3.90	4.10	.....
27	7.90	18.40	7.25	6.20	4.60	3.50	3.90	3.95	4.00	.....
28	9.40	18.40	7.20	6.00	4.55	3.80	4.00	3.85	3.90	.....
29	9.40	18.40	7.05	6.00	4.40	3.70	3.90	3.90	4.00	.....
30	[e] 10.35	18.40	6.85	6.00	4.70	3.10	4.00	3.90	[f] 4.00	.....
31	11.40	.....	6.65	.....	4.60	3.80	.....	3.80	.....	.....

[a] Ice 6 inches thick.
[b] Ice jam.
[c] Ice 3 feet thick.
[d] 4 inches of water on top of ice.
[e] Ice breaks up.
[f] Ice 1 inch thick.

Rating table for Sheyenne River near Haggart, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	32	4.70	157	6.40	340	9.00	654
3.10	36	4.80	167	6.50	351	9.20	680
3.20	41	4.90	177	6.60	362	9.40	706
3.30	47	5.00	187	6.70	373	9.60	732
3.40	53	5.10	197	6.80	384	9.80	758
3.50	59	5.20	208	6.90	396	10.00	784
3.60	66	5.30	219	7.00	408	10.50	849
3.70	73	5.40	230	7.20	432	11.00	914
3.80	80	5.50	241	7.40	456	11.50	980
3.90	87	5.60	252	7.60	480	12.00	1,050
4.00	95	5.70	263	7.80	504	13.00	1,190
4.10	103	5.80	274	8.00	528	14.00	1,330
4.20	112	5.90	285	8.20	552	15.00	1,470
4.30	121	6.00	296	8.40	576	16.00	1,610
4.40	130	6.10	307	8.60	602	17.00	1,750
4.50	139	6.20	318	8.70	615	18.00	1,890
4.60	148	6.30	329	8.80	628	19.00	2,030

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is not well defined. Above gage height 12.0 feet the rating curve is a tangent, the difference being 14 per tenth.

Estimated monthly discharge of Sheyenne River near Haggart, N. Dak., for 1904.

[Drainage area, 5,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April[a]	1,974	1,036	1,553	92,410	0.288	0.321
May	1,946	368	1,043	64,130	.193	.222
June	654	285	420	24,990	.078	.087
July	296	130	217	13,340	.040	.046
August	130	36	88	5,411	.016	.018
September	112	32	85.1	5,064	.016	.018
October	148	80	93.2	5,731	.017	.020
November	103	80	91.3	5,433	.017	.019
The period				216,500		

[a] During the greater part of April backwater was caused by ice gorge. Estimate for the month probably somewhat large.

RED LAKE RIVER AT CROOKSTON, MINN.

This station was established May 19, 1901, by C. M. Hall. It is located at the bridge which connects Robert and St. Paul streets, and which is known as the Sampson Addition Bridge. It is about one-sixth mile west of the Great Northern Railway station. The low-water vertical gage is a 1 by 6 inch board, graduated to feet and tenths, fastened to the piling of the left abutment under the bridge. It reads from 0 to 9.6 feet. The high-water vertical gage is attached to the piling of the pier at the right end of the bridge. It reads from 7.5 to 15 feet. There is also a wire gage near the middle of the single-span bridge. Its horizontal scale reads from 3 to 19 feet. The gage is read once each day by J. E. Carroll, the city engineer. Discharge measurements are made from the lower side of the single-span bridge at which the gages are located. The initial point for soundings is the post of the hand rail, lower side, at the left end of the bridge, at a point where the diagonal member of the bridge truss meets the floor timbers. The channel is straight for 250 feet above and 200 feet below the station. The current is swift. The right bank is low and is covered with trees and brush. It is liable to overflow at very high stages, but there would be little current in the flooded section, owing to the trees and brush. The left bank is high, wooded, and not liable to overflow. The bed of the stream is sandy, free from vegetation, and shifting. The dam and power house for the city waterworks are located about 1,000 feet above the gage. The opening and closing of the sluices cause some variation in the flow, but the gage readings represent a close average of the daily river height. Bench mark No. 1 is the top of the hydrant at the corner of St. Paul and Robert streets, 30 feet south of the bridge. Its elevation is 24.23 feet above gage datum. Bench mark No. 2 is the top of a hydrant 200 feet north of the bridge at the corner of St. Paul and Woodlawn streets. Its elevation is 27.46 feet above the zero of the gage. The city datum of Crookston has an elevation of 4.10 feet above gage datum. The top of the rail of the main track at the Great Northern Railway station at Crookston has an elevation of 37.63 feet above gage datum. The gage datum has an elevation of 825 feet above sea level.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Red Lake River at Crookston, Minn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 15	E. F. Chandler	193	2,535	2.33	16.50	5,915
April 26	do	203	3,007	3.98	18.46	11,970
May 16	R. Richards	201	1,693	3.65	11.58	6,184
June 9	E. C. Murphy	183	1,077	3.23	8.48	3,486
July 16	R. Richards	177	671	2.76	6.26	1,854
August 17	do	173	357	2.13	4.40	759
September 9	do	176	526	2.21	5.36	1,164
October 24	do	177	498	2.44	5.20	1,208

Mean daily gage height, in feet, of Red Lake River at Crookston, Minn., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					13.32	8.65	7.35	5.33	5.60	4.40	5.05	3.80
2					12.42	8.40	7.25	5.30	5.40	5.10	5.00	4.10
3				8.80	11.95	8.25	7.15	5.00	5.35	4.50	4.85	3.79
4				11.55	11.30	8.38	6.95	5.30	5.40	5.00	4.75	3.80
5				15.68	10.90	8.55	6.90	5.28	5.30	4.85	.....	3.70
6				18.03	10.55	8.55	7.10	5.10	5.60	4.85	4.60	4.50
7				18.30	11.35	8.60	6.70	4.50	5.35	5.00	4.50	4.70
8				17.01	11.90	8.80	6.80	4.90	5.35	4.50	5.00	4.65
9				15.12	11.90	8.85	6.65	4.92	5.40	5.15	5.20	4.80
10				13.98	11.90	8.70	6.15	4.70	5.35	4.60	5.40	4.80
11				15.42	11.60	8.60	6.45	4.55	4.70	4.75	5.15	4.70
12				17.90	11.68	8.60	6.45	4.50	5.10	4.75	4.85	5.05
13				16.85	11.68	8.70	6.35	4.50	4.60	4.93	4.85	5.50
14				16.55	11.95	8.10	6.15	4.75	4.70	4.63	5.00	5.30
15				16.35	11.80	7.85	5.85	4.70	4.85	5.10	5.05	5.60
16				15.85	11.80	7.75	6.35	4.50	4.85	4.50	5.15	5.40
17				15.47	11.40	7.75	5.95	4.53	4.25	4.70	.....	5.50
18				13.08	10.80	8.00	6.20	4.60	4.20	4.90	4.80	5.40
19				14.85	10.57	8.60	5.95	4.63	4.15	4.75	4.60	5.40
20				12.72	10.40	8.50	5.65	4.63	4.90	4.80	.....	5.50
21				13.20	10.10	8.05	5.55	4.45	4.05	5.05	4.40	5.65
22				15.10	9.20	8.05	5.60	4.60	4.40	4.93	4.20	5.65
23				[b]19.13	9.82	8.10	5.58	4.65	4.58	5.05	.....	5.09
24				20.32	9.52	7.95	5.70	4.65	4.80	5.15	4.30	5.10
25				19.50	9.50	7.90	5.58	4.55	4.50	4.80	4.10	5.10
26				18.30	9.30	8.00	5.65	4.70	4.60	5.10	4.25	5.10
27				16.40	9.30	8.15	5.60	4.50	4.80	5.10	3.60	(c)
28				15.65	9.30	7.80	5.40	4.65	4.35	5.10	3.70	.....
29				15.05	8.85	7.60	5.32	4.30	4.45	5.40	3.90	.....
30				13.90	8.70	7.75	5.15	4.50	4.90	5.20	3.90	.....
31				.....	8.78	.....	5.00	4.90	.....	4.60	.....	.....

[a] River frozen over from January 1 to April 2.
[b] Rise at the rate of 1½ inches per hour during day.
[c] Channel frozen underneath gage, 20 feet channel open.

Rating table for Red Lake River at Crookston, Minn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.60	430	5.00	1,090	6.40	1,980	8.60	3,620
3.70	470	5.10	1,150	6.50	2,050	8.80	3,780
3.80	510	5.20	1,210	6.60	2,120	9.00	3,950
3.90	550	5.30	1,270	6.70	2,190	10.00	4,800
4.00	590	5.40	1,330	6.80	2,260	11.00	5,650
4.10	630	5.50	1,390	6.90	2,330	12.00	6,500
4.20	670	5.60	1,450	7.00	2,400	13.00	7,350
4.30	710	5.70	1,510	7.20	2,540	14.00	8,200
4.40	760	5.80	1,570	7.40	2,680	15.00	9,050
4.50	810	5.90	1,630	7.60	2,820	16.00	9,900
4.60	860	6.00	1,700	7.80	2,980	17.00	10,750
4.70	910	6.10	1,770	8.00	3,140	18.00	11,600
4.80	970	6.20	1,840	8.20	3,300	19.00	12,450
4.90	1,030	6.30	1,910	8.40	3,460	20.00	13,300

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is fairly defined. Above gage height 9 feet the rating curve is a tangent, the difference being 85 per tenth.

Estimated monthly discharge of Red Lake River at Crookston, Minn., for 1904.

[Drainage area, 5,525 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April 3–30	13,570	3,780	7,410	411,500	1.34	1.40
May	7,622	3,700	5,446	334,900	.986	1.14
June	3,822	2,820	3,341	198,800	.605	.675
July	2,645	1,090	1,817	111,700	.329	.379
August	1,288	710	938	57,680	.170	.196
September	1,450	610	1,020	60,690	.185	.206
October	1,330	760	1,021	62,780	.185	.213
November	1,330	430	893	53,140	.162	.181
December 1–26	1,480	470	1,059	54,610	.192	.186
The period				1,346,000		

PEMBINA RIVER NEAR NECHE, N. DAK.

This station was established April 29, 1903, by F. E. Weymouth, assisted by E. F. Chandler. At this time a temporary gage was put in. The permanent gage was installed by E. F. Chandler May 18, 1903. It is located at the Great Northern Railway bridge, two-thirds of a mile north of the railroad station at Neche, N. Dak. The gage is near the northeast corner of sec. 36, T. 164 N., R. 54 W. It consists of two sections of 1 by 6 inch plank painted white and divided into feet and tenths. The lower section, reading from 0 to 5 feet, is driven 2 feet into the bed of the stream, and has its upper end spiked to the bridge abutment timbers on the left bank. The upper section, reading from 5 to 24 feet, is spiked to the bridge pier on the right bank. It is read once each day by P. J. Horgan. Discharge measurements are made from the single-span highway bridge, 400 feet below the gage. The initial point for soundings is a point on the downstream hand rail 3 feet from its right end. The bridge crosses the river obliquely. To take this fact into account, the hand rail has been divided into intervals of 10.4 feet. This is equivalent to 10-foot intervals of a cross section normal to the direction of the current. The channel is straight for 100 feet above and below the station. Both banks extend about 20 feet above the zero of the gage. They are not liable to overflow except at exceptionally high stages. The right bank is densely wooded and the left bank is covered with brush. The bed of the stream is composed of sand and of mud, in which there are some sunken snags. The bed may change slightly. About one-third of a mile below the gage there is a loose-rock dam 4 feet high. This raises the water 1 or 2 feet at the bridge, but, as the dam is not tight, the water may fall at low stages. Bench mark No. 1 is the top of the horizontal timber on the upstream side of the right pier, near the gage. It is marked with brass-headed nails, and has an elevation of 23.70 feet above the zero of the gage. Bench mark No. 2 is the west rail of the track at the rail joint at the crossing about 550 feet south of the gage. Its elevation is 26.54 feet above the zero of the gage. Bench mark No. 3 is a spike driven in the north face of the telephone pole inside the fence in the field west of the track and about 550 feet south of the gage. It is about 1½ feet above the ground and has an elevation of 24.28 feet above the zero of the gage. The elevation of the top of the 12 by 12 inch timber, to which the low-water gage is fastened, is 4.93 feet. The elevation of the zero of the gage above sea level, as determined by hand level from the railroad station at Neche, N. Dak., is 815 feet. The drainage area of Pembina River at this station is 2,800 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Pembina River near Neche, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 18	R. Richards	85	634	1.93	11.85	1,227
April 26	do	92	1,494	2.14	18.12	3,198
May 23	do	96	909	2.45	13.28	2,230
June 8	E. C. Murphy	86	837	2.12	12.04	1,778
July 9	R. Richards	79	488	1.99	8.51	971
August 16	do	72	299	1.22	5.70	363
October 17	L. L. Wilcox	70	274	.91	5.22	249

Mean daily gage height, in feet, of Pembina River near Neche, N. Dak., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					20.7	10.2	8.1	6.0	5.5	5.0	5.0	
2					20.9	9.9	7.9	6.0	5.5	5.0	5.0	
3					20.7	9.9	8.9	6.0	5.5	5.0	5.0	
4				3.7	20.3	9.9	15.2	6.0	5.5	5.0	5.0	
5				3.8	19.9	14.0	16.0	6.0	5.5	5.0	5.0	
6				4.0	19.3	13.8	11.8	6.0	5.5	5.0	5.0	
7				4.5	18.6	13.3	9.7	6.0	5.5	5.0	5.0	
8				5.0	18.0	12.0	9.5	6.0	5.5	5.0	5.0	
9				[b]7.0	17.4	11.0	8.6	6.0	5.5	5.0	5.0	
10				9.3	16.8	11.8	8.0	6.0	5.5	5.0	5.0	
11				9.4	16.4	13.8	7.8	5.9	5.5	5.0	5.0	
12				10.0	16.0	15.2	7.6	5.9	5.5	5.0	5.0	
13				11.7	16.5	15.3	7.6	5.8	5.5	5.0	5.0	
14				12.2	16.9	14.0	7.3	5.8	5.4	5.0	4.9	
15				13.5	17.5	12.8	7.0	5.8	5.4	5.0	4.9	
16				13.8	17.7	12.0	6.9	5.8	5.4	5.0	4.8	
17				12.9	16.3	11.3	6.9	5.8	5.3	5.0	4.7	
18				11.8	15.4	10.5	6.9	5.7	5.3	5.1	4.6	
19				12.4	14.6	10.4	6.8	5.7	5.4	5.2	4.5	
20				15.3	14.1	9.7	6.8	5.7	5.4	5.2	4.5	
21				16.2	13.9	9.5	6.8	5.9	5.5	5.3	4.5	
22				16.8	13.3	13.1	6.8	5.9	5.5	5.3	4.5	
23				17.0	13.3	13.2	6.7	5.9	5.5	5.3	4.5	
24				17.8	13.0	13.4	6.5	5.9	5.5	5.3	4.5	
25				18.0	12.5	12.7	6.2	5.8	5.5	5.3	4.5	
26				18.2	12.0	11.1	6.0	5.7	5.4	5.3	4.5	
27				18.2	11.8	10.3	6.0	5.7	5.4	5.3	[a]	
28				18.3	11.4	9.1	6.0	5.6	5.3	5.2		
29				19.0	11.1	8.4	5.9	5.5	5.2	5.1		
30				19.7	10.8	8.3	6.0	5.5	5.1	5.0		
31					10.5		6.0	5.5		5.0		

[a] River frozen January 1 to April 8 and November 27 to December 31, inclusive.
[b] Ice broken up.

Miscellaneous measurements in the Hudson Bay drainage basin (St. Mary River subdrainage basin) in 1904.

[Under the direction of C. C. Babb, district engineer.]

Date.	Stream.	Locality.	Area of section.	Mean velocity.	Discharge.
			Sq. feet.	*Ft. per sec.*	*Sec.-feet.*
July 12	St. Mary canal	Kimballward, Alta	71	2.35	167
July 30	do	do	68	2.37	161

MINNESOTA RIVER DRAINAGE BASIN.

Minnesota River rises in Bigstone Lake, which forms part of the boundary between South Dakota and Minnesota. The river flows in a southeasterly direction to the city of Mankato, in the northern part of Blue Earth County, where it makes an abrupt turn to the north and continues in a northerly and northeasterly direction, entering Mississippi River at a point midway between Minneapolis and St. Paul.

The course of this river is generally marked by wide bottom lands. It has a sluggish current, affording few opportunities for the development of water power. The United States Geological Survey maintains a gaging station at Mankato, below the junction of Blue Earth River, mainly for the study of the sewage disposal of the city of Mankato, and for the purpose of ascertaining the run-off in the southern part of Minnesota.

MINNESOTA RIVER ABOVE MANKATO, MINN.

This station was established May 20, 1903, by E. Johnson, jr., assisted by W. R. Hoag. It is located at Sibley Park, 1 mile below the highway and railroad bridges across Blue Earth River and 1½ miles above the city bridge in Mankato. The drainage area above the station is about 13,400 square miles. Blue Earth River joins the Minnesota about 500 feet above the station. The gage is a vertical timber, divided into feet and tenths, fastened to a post, which is driven into the river bed a few feet from the right bank. It is read once each day by George E. Blake. On February 4, 1904, a new $\frac{5}{16}$-inch galvanized cable was stretched across the river between trees on the banks. The old $\frac{1}{4}$-inch wire cable from which measurements were previously made was left undisturbed and will be used as a tag line. The new cable is wound with heavy wire every 25 feet. The first point at which wire is wound is 17.34 feet from the tree to which the cable is attached. Discharge measurements are made from a small rowboat running on this cable. The initial point for soundings is a spike in the base of the willow tree to which the small cable is attached

on the right bank; it is about 15 feet from the top of the bank. The channel is straight for 1,000 feet above and 2,000 feet below the station. The current velocity is moderate, though somewhat sluggish near the banks at low stages. The width of the channel is about 300 feet at low water and about 350 feet at high stages. The right bank is low and liable to overflow for a distance of 50 to 75 feet from the gage. The left bank is a steep, rocky bluff. The bed of the stream is composed of sand, gravel, and blue earth, and may shift somewhat at high water. There is but one channel at all stages. The bench mark is on a 20-inch cottonwood tree on the right bank, a short distance above the station and about 30 feet from the water's edge. Its elevation is 14.78 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Minnesota River above Mankato, Minn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
January 17	E. Johnson, jr	365	1,133	0.51	2.30	580
April 21	E. F. Chandler	302	2,004	2.45	6.48	4,909
June 28	do	286	1,039	2.09	3.74	2,172
July 26	R. Richards	282	773	1.41	2.70	1,092
August 31	do	270	614	.89	2.09	548
October 18	E. F. Chandler	270	616	1.08	2.24	665
December 30	R. Richards	220	498	.63	[a]2.20	315

[a] Gage height of under surface of ice = 1.70.

Mean daily gage height, in feet, of Minnesota River above Mankato, Minn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	2.00	2.00	5.20	6.40	3.45	3.50	2.75	2.10	1.90	2.60	2.15
2	3.10	2.00	2.00	5.10	6.15	3.50	3.40	2.70	2.40	1.90	2.55	2.15
3	2.10	2.00	2.00	4.95	6.00	3.60	3.35	2.60	2.55	1.90	2.55	2.15
4	2.90	2.00	2.00	4.90	5.80	3.85	3.30	2.50	2.40	1.90	2.55	[a]2.10
5	2.85	2.00	2.00	4.90	5.60	4.80	3.25	2.45	2.40	1.90	2.50	2.10
6	2.70	2.00	2.10	4.80	5.65	4.90	3.20	2.40	2.35	1.90	2.50	2.10
7	2.50	2.00	2.20	4.70	5.70	4.20	3.10	2.35	2.30	1.90	2.50	2.10
8	2.40	2.00	2.30	4.60	5.60	4.20	3.05	2.35	2.30	1.90	2.45	2.10
9	2.35	2.00	2.45	5.60	5.50	4.25	3.00	2.50	2.30	1.90	2.45	2.10
10	2.30	2.00	2.40	6.70	5.40	4.25	3.10	2.55	2.20	2.00	2.45	2.10
11	2.25	2.00	2.50	7.60	5.30	4.25	3.10	2.50	2.20	2.10	2.40	2.10
12	2.25	2.00	2.60	8.30	5.10	4.20	3.00	2.40	2.20	2.10	2.40	2.10
13	2.20	2.00	2.70	8.30	5.00	4.15	3.00	2.40	2.15	2.10	2.40	2.10
14	2.20	2.00	2.80	8.10	4.90	4.10	3.00	2.30	2.10	2.10	2.40	2.10
15	2.15	2.00	2.90	7.85	4.70	4.00	2.90	2.30	2.10	2.10	2.40	2.00
16	2.15	2.00	3.00	7.60	4.60	3.80	2.80	2.30	2.10	2.10	2.40	2.00
17	2.10	2.00	3.00	7.40	4.50	3.70	2.70	2.30	2.10	2.10	2.30	2.00
18	2.10	2.00	[b]3.10	7.10	4.35	3.70	2.70	2.25	2.00	2.20	2.30	2.00

[a] River frozen. [b] Ice unbroken.

Mean daily gage height, in feet, of Minnesota River above Mankato, Minn., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
19	2.10	2.00	3.10	6.90	4.20	3.60	2.70	2.25	2.00	2.30	2.30	2.00
20	2.00	2.00	4.00	6.70	4.15	3.60	2.60	2.20	2.00	2.55	2.30	2.00
21	2.00	2.00	4.10	6.50	4.10	3.55	2.60	2.20	2.00	2.70	2.30	1.80
22	2.00	2.00	4.20	6.70	4.00	3.50	2.55	2.20	2.00	2.80	2.30	1.80
23	2.00	2.00	4.30	7.10	3.95	3.45	2.50	2.15	2.00	2.85	2.30	1.80
24	2.00	2.00	4.50	7.40	3.90	3.50	2.50	2.10	2.00	2.80	2.30	1.80
25	2.00	2.00	4.60	7.40	3.80	3.55	2.50	2.10	1.90	2.80	2.25	1.80
26	2.00	2.00	4.70	7.30	3.80	3.75	2.70	2.00	1.90	2.75	2.25	1.80
27	2.00	2.00	5.00	7.30	3.70	3.80	2.65	2.00	1.90	2.70	2.20	1.80
28	2.00	2.00	5.10	7.10	3.65	3.75	2.60	2.00	1.90	2.70	2.20	2.20
29	2.00	2.00	5.20	6.80	3.60	3.70	2.60	2.00	1.90	2.70	2.20	2.20
30	2.00	.....	5.20	6.65	3.55	3.60	2.75	2.00	1.90	2.70	2.20	2.20
31	2.00	.....	5.25	.....	3.50	.....	2.80	2.00	.....	2.65	.....	2.20

WAPSIPINICON RIVER DRAINAGE BASIN.

Wapsipinicon River rises in Mower County, Minn., and flows southeast, entering the Mississippi near Shaffton, Scott County, Iowa. There are numerous small power sites on this stream at Toronto, O ford Mills, Newport, Anamosa, Central City, Troy Mills, Quasqueton, Independence, and Littleton. At several of these points, notably at Anamosa, there are good opportunities for building dams.

The river is generally fairly constant in its flow, though its headwaters are sometimes low. As a rule, its banks are fairly high and the stream is well confined. The United States Geological Survey maintains a gaging station at Stone City.

The total drainage area of the Wapsipinicon River is 2,304 square miles; that at Stone City, where the United States Geological Survey has its station, is 1,308 square miles.

WAPSIPINICON RIVER AT STONE CITY, IOWA.

This station was established August 19, 1903, by F. W. Hanna. It is located at the highway bridge just above the Chicago, Milwaukee and St. Paul Railway bridge and near the Dearborn stone quarry. There is a dam at Waubeck, 4 miles above the station, and another at Anamosa, the same distance below. A standard boxed chain gage is attached to the guard rail on the upstream side of the bridge. The length of the chain from the end of the weight to the marker is 36.4 feet. The gage is read once each day by Frank Dearborn. Discharge measurements are made from the two-span Pratt truss highway bridge, which has a length of 225 feet. The initial point for soundings is the end of the lower chord on the upstream side of the bridge at the left bank. The channel is straight for about 400 feet above and below the station, at which points the river makes abrupt turns. Both banks

are high and are not subject to overflow. The bed of the stream is of solid rock and sand and is permanent. The channel is broken by one pier, and the current velocity is moderate. Bench mark No. 1 is the east end of the south rail west of the first switch east of the railroad station at Stone City. Its elevation is 815.08 feet above sea level and 38.75 feet above gage datum. Bench mark No. 2 is a cross on the northwest corner of the middle pier of the highway bridge at which the station is located. Its elevation is 31.09 feet above gage datum and 807.42 feet above sea level. The center of the gage pulley is at an elevation of 35.58 feet above gage datum and 811.91 feet above sea level. The top of the lower chord, upstream side, at the first cross girder east of the pier is 31.75 feet above gage datum. The elevations of the bench marks above sea level have been determined by Chicago, Milwaukee and St. Paul Railway levels. During the spring of 1904 a new railroad bridge was erected 100 feet below the station. The two new piers of the bridge changed the station conditions to such an extent that the measurements prior to June 7 are not comparable to those for the remainder of the year.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Wapsipinicon River at Stone City, Iowa, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
January 14 [a]	F. W. Hanna	125	190	0.50	1.54	96
March 16 [b]	do	158	342	1.60	4.60	547
April 20	do	139	485	1.32	3.70	641
May 26	Hanna and Johnson	139	436	.64	3.30	281
June 7	F. W. Hanna	139	509	1.11	3.80	567
July 12	do	139	384	.98	3.31	377
August 16	do	131	248	.44	2.36	108
September 6	do	137	295	.61	2.72	180
October 22	E. Johnson, jr	136	296	.53	2.68	156
November 12	F. W. Hanna	132	226	.41	2.44	93

[a] River frozen. Gage height to under surface of ice.
[b] Ice conditions.

Mean daily gage height, in feet, of Wapsipinicon River at Stone City, Iowa, for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	.....	b 4.58	5.62	3.90	5.05	3.30	2.55	2.32	2.40	2.48	2.18
2	.....	.....	4.55	5.27	3.76	4.65	3.30	2.52	2.42	2.36	2.46	2.25
3	.....	.....	4.92	4.97	3.68	5.45	3.45	2.50	2.50	2.40	2.46	2.25
4	.....	c 2.6	5.57	4.47	3.63	4.95	3.50	2.45	2.42	2.43	2.43	(d)
5	.....	2.9	5.92	4.32	3.57	4.10	3.40	2.42	2.50	2.46	2.46	.....
6	.....	b 4.8	e 5.8	4.15	3.48	3.95	3.75	2.40	2.70	2.46	2.48	.....
7	.....	f 4.7	5.7	4.10	3.56	3.90	3.90	2.37	2.75	2.48	2.46	g 2.23
8	2.4	4.3	5.0	4.32	3.60	3.90	3.75	2.35	2.80	2.46	2.42	.....
9	.....	4.2	4.9	4.58	3.68	3.85	3.60	2.32	2.70	2.76	2.41	.....
10	.....	4.1	4.9	4.82	3.58	3.60	3.45	2.30	2.64	2.58	2.36	.....
11	.....	4.0	4.7	4.92	3.48	3.45	3.40	2.40	2.60	2.51	2.32	.....
12	(h)	3.9	4.6	4.62	3.43	3.37	3.30	2.42	2.58	2.48	2.36	.....
13	.....	i 3.9	4.6	4.27	3.58	3.30	3.27	2.55	2.57	2.46	2.38	.....
14	2.8	3.8	4.6	4.12	3.73	3.22	3.25	2.48	2.52	2.46	2.35	j 2.28
15	.....	3.7	4.6	4.02	3.66	3.15	3.20	2.45	2.54	2.46	2.35	.....
16	.....	3.7	4.6	4.00	3.55	3.27	3.10	2.40	2.51	2.56	2.40	.....
17	(h)	3.6	5.0	3.96	3.40	3.20	3.02	2.38	2.48	2.81	2.55	.....
18	.....	.....	5.38	3.92	3.33	3.20	3.00	2.40	2.48	2.76	2.52	.....
19	.....	.....	k 6.45	3.82	3.30	3.20	2.95	2.48	2.43	2.76	2.44	.....
20	.....	3.6	7.55	3.70	3.30	3.15	2.90	2.45	2.43	2.74	2.42	.....
21	2.8	.....	l 9.60	3.66	3.25	3.70	2.87	2.52	2.40	2.71	2.40	m 2.4
22	.....	3.6	7.75	3.60	3.25	3.70	2.82	2.54	2.35	2.68	2.42	.....
23	.....	.....	7.70	3.55	3.20	3.60	2.78	2.48	2.40	2.70	2.46	.....
24	(c)	.....	7.95	3.62	3.15	3.50	2.75	2.40	2.38	2.68	2.50	.....
25	.....	.....	8.70	4.05	3.40	3.45	2.72	2.40	2.46	2.65	2.52	.....
26	.....	3.6	10.05	4.62	3.50	3.50	2.80	2.35	2.48	2.60	2.55	.....
27	.....	3.6	11.70	4.96	3.55	3.45	2.75	2.30	2.48	2.55	2.50	.....
28	.....	4.40	11.45	4.85	4.65	3.35	2.70	2.28	2.53	2.50	2.35	.....
29	.....	3.70	9.55	4.58	5.50	3.30	2.68	2.42	2.48	2.48	2.18	.....
30	2.6	.....	6.75	4.25	6.45	3.35	2.65	2.40	2.46	2.48	2.15	m 2.2
31	.....	.....	6.15	.....	6.05	.....	2.60	2.35	.....	2.48	.....	.....

a Ice 14 inches thick.
b Measured to water running over ice.
c Ice 16 to 24 inches thick.
d Ice 3.5 inches thick.
e Ice 18 inches thick.
f Ice broken up.
g Ice 3.5 inches thick.
h Ice 16 inches thick.
i Ice about 16 inches thick.
j Ice 5.5 inches thick.
k Ice breaking up.
l Ice went out.
m Ice 10.5 inches thick.

NOTE.—Gage heights to surface of water.

Rating table for Wapsipinicon River at Stone City, Iowa, from June 7 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	50	2.80	203	3.40	398	4.00	660
2.30	73	2.90	232	3.50	436	4.10	712
2.40	97	3.00	262	3.60	476	4.20	766
2.50	122	3.10	294	3.70	518		
2.60	148	3.20	327	3.80	563		
2.70	175	3.30	362	3.90	610		

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1904. It is well defined between gage heights 2.40 feet and 3.80 feet. The table has been extended beyond these limits. (See note in station description.)

Estimated monthly discharge of Wapsipinicon River at Stone City, Iowa, for 1904.

[Drainage area, 1,308 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
June 7–30	610	310	420	0.321	0.286
July	610	148	313	.239	.276
August	135	68	102	.078	.090
September	203	78	125	.096	.107
October	206	87	138	.106	.122
November	135	39	102	.078	.087

IOWA RIVER DRAINAGE BASIN.

Iowa River rises in the north-central part of Iowa, flows in a southeasterly direction, and joins Mississippi River about 30 miles above Burlington. Its chief tributary is Cedar River, which rises in Minnesota and flows into the Iowa about 50 miles above the latter's mouth.

The total drainage area of Iowa River is 12,410 square miles, 4,470 square miles of this being tributary to it above its junction with Cedar River at Columbus Junction. Its drainage areas at Marshalltown and Iowa City are, respectively, 1,463 and 3,317 square miles. Cedar River drains 7,597 square miles above its union with Iowa River and 6,317 square miles at Cedar Rapids.

The chief power plants in the Iowa River drainage basin are at Iowa City, Marshalltown, Cedar Rapids, Waterloo, and Cedar Falls. From the standpoint of power development the Iowa River system is important.

During 1904 stations have been maintained on Cedar River at Cedar Rapids, Iowa, and on Iowa River at Iowa City, Iowa.

IOWA RIVER AT IOWA CITY, IOWA.

This station was established June 1, 1903, by F. W. Hanna. At that time a chain gage was installed on the county bridge directly west of the State University grounds. On September 15, 1903, the standard boxed chain gage was substituted for the gage which was first established and made to read the same, with the same length of chain from the end of the weight to the marker. This length is 24.43 feet. On June 8, 1904, the length of the weight and chain to the marker was changed to 26.48 feet, the gage datum remaining the same. The gage is read twice each day by Arthur G. Smith. Discharge measurements are made from the upstream side of the two-span highway bridge at the foot of Burlington street, about 1,000 feet below the bridge at which the gage is located. The initial point for soundings is the inner face of the right abutment, located at the west end of the bridge, and is marked zero on the bridge floor. The bridge is not quite at right-angles with the direction of the current. The channel is straight for about 1,600 feet above and below the station. The channel is 316 feet wide between abutments, and is broken by one pier. The bed of the stream is of soft material, except near the bridge pier, and is slightly shifting. The right bank is high and somewhat rocky and not liable to overflow. The left bank does not overflow, owing to the road embankment. Both banks are covered with willows above ordinary high-water mark, which will interfere with flood measurements. Bench mark No. 1 is on the top stone just north of and against the northwest railing post of the bridge at which the gage is located. Its elevation above gage datum is 22.67 feet, and above the city datum is 64.72 feet and 672.06 feet above sea level. The city bench mark used for reference is on the north side of the base of a maple tree, one block east and one block and 40 feet south of the bridge at which the gage is located. The elevation of this bench mark is 22.53 feet above gage datum, 64.58 feet above the city datum, and 671.92 feet above sea level. The elevation above sea level was obtained from the levels of the Chicago, Rock Island and Pacific Railway. The bottom of the top hand rail, just above the pulley center, has an elevation of 26.73 feet above gage datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Iowa River at Iowa City, Iowa, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
January 15[a]	F. W. Hanna	162	460	0.38	−1.54	175
April 20	do	211	980	1.53	1.30	1,500
May 27	Johnson and Hanna	187	817	1.11	.37	908
June 8	F. W. Hanna	213	1,051	1.59	1.59	1,846
July 12	do	188	833	1.24	.46	1,033
August 17	do	165	567	.57	−1.26	321
September 7	do	183	754	1.04	.00	784
October 21	E. Johnson, jr	159	490	.40	−1.41	198
November 13	F. W. Hanna	162	492	.37	−1.46	184

[a] River frozen.

Mean daily gage height, in feet, of Iowa River at Iowa City, Iowa, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1			3.25	1.95	2.86	2.3	0.95	−0.97	−1.25	−1.4	−1.45	−1.7
2			3.15	1.65	2.51	2.15	.97	− .92	− .7	−1.45	−1.3	−1.8
3			3.3	1.55	2.21	1.9	.75	− .87	− .9	−1.5	−1.4	−1.7
4			3.35	1.4	1.96	1.9	.65	−1.10	−1.1	−1.45	−1.35	−1.8
5		3.2	3.7	1.18	1.66	1.45	.55	−1.12	− .9	−1.35	−1.38	−1.4
6		4.95	3.2	1.05	1.46	1.3	.50	−1.12	− .2	−1.3	−1.4	−1.6
7		3.0	2.75	1.0	1.76	1.45	.55	−1.27	− .1	−1.25	−1.3	−1.7
8			2.4	1.65	2.16	1.6	.45	−1.27	− .2	−1.35	−1.45	−1.7
9	−0.27		2.1	1.5	2.41	1.7	1.00	−1.07	− .3	−1.15	−1.3	−1.6
10			1.9	1.55	1.86	1.7	.90	−1.24	− .45	−1.2	−1.4	−1.6
11			1.6	1.72	1.56	1.65	.62	−1.35	− .5	−1.25	−1.5	−1.7
12			1.15	2.05	1.36	1.45	.44	−1.43	− .65	−1.25	−1.3	−1.7
13		1.1	1.1	1.8	1.66	1.25	.52	−1.3	− .65	−1.3	−1.45	−1.3
14			1.0	1.85	1.51	1.2	.62	−1.4	− .8	−1.3	−1.35	
15			0.5		1.56	.9	.87	−1.3	− .9	−1.35	−1.5	
16	− .20		0.4		1.39	.8	.27	−1.3	−1.0	−1.3	−1.1	
17			3.15		1.29	.65	.92	−1.3	−1.0	−1.35	−1.4	−1.6
18			1.95	1.7	1.14	.5	− .08	−1.3	−1.1	−1.25	−1.45	
19			2.7	1.55	.99	.45	.07	−1.32	−1.1	−1.1	−1.2	
20		.1	2.45	1.33	.94	.45	.02	−1.38	−1.1	−1.25	−1.45	
21	[c]3.68		2.25	1.13	.84	.53	.15	−1.4	−1.1	−1.3	−1.3	
22	2.00		2.8	1.13	.69	.30	.60	−1.1	−1.15	−1.45	−1.6	
23	.70		2.95	1.50	.64	.13	.65	−1.1	−1.2	−1.5	−1.5	−1.8
24	.70		3.4	2.93	.39	.33	.3	−1.2	−1.05	−1.5	−1.2	−1.6
25			7.8	4.68	.39	1.13	− .05	−1.25	−1.25	−1.55	−1.6	−1.7
26			4.8	5.28	.44	1.23	− .25	−1.35	−1.35	−1.3	−1.7	−1.6
27		.1	4.4	4.33	.39	1.03	− .3	−1.35	−1.15	−1.45	−1.5	
28			4.42	4.68	.78	.93	− .38	−1.4	−1.3	−1.35	−1.5	
29		[c]4.25	3.1	4.83	1.2	1.13	− .6	−1.0	−1.3	−1.35	−1.6	
30	[d]− .30		2.15	4.28	1.6	1.23	− .6	− .9	−1.4	−1.45	−1.4	
31			2.1		2.05		− .8	−1.25		−1.45		[e]−1.4

[a] River frozen January 1 to March 24, inclusive.
[b] River frozen at station December 1 to 31, inclusive.
[c] Heavy thaw.
[d] Ice 21 inches thick.
[e] Ice 6 inches thick.

Note.—Gage heights read to water surface during frozen period.

Rating table for Iowa River at Iowa City, Iowa, from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−1.70	160	.00	680	1.70	1,780	4.80	4,920
−1.60	179	.10	730	1.80	1,860	5.00	5,160
−1.50	199	.20	780	1.90	1,950	5.50	5,785
−1.40	220	.30	830	2.00	2,040	6.00	6,410
−1.30	242	.40	880	2.20	2,220	6.50	7,085
−1.20	266	.50	940	2.40	2,400	7.00	7,760
−1.10	292	.60	1,000	2.60	2,580	7.50	8,460
−1.00	320	.70	1,060	2.80	2,780	8.00	9,160
−.90	350	.80	1,120	3.00	2,980	8.50	9,885
−.80	380	.90	1,180	3.20	3,180	9.00	10,610
−.70	410	1.00	1,250	3.40	3,380	9.50	11,360
−.60	445	1.10	1,320	3.60	3,580	10.00	12,110
−.50	480	1.20	1,390	3.80	3,800	11.00	13,610
−.40	520	1.30	1,460	4.00	4,020	12.00	15,210
−.30	560	1.40	1,540	4.20	4,240	13.00	16,810
−.20	600	1.50	1,620	4.40	4,460	14.00	18,410
−.10	640	1.60	1,700	4.60	4,680	15.00	20,010

The above table is applicable only for open-channel conditions. It is based upon 18 discharge measurements made during 1903 and 1904. It is well defined between gage heights −1.40 feet and 2.40 feet. Two flood measurements define the table above gage height 2.40 feet. It is the same as the 1903 table above 5.0 feet.

Estimated monthly discharge of Iowa River at Iowa City, Iowa, for 1904.

[Drainage area, 3,317 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March, 7 days	8,880	2,130	4,304	1.30	0.338
April[a]	5,510	1,250	2,330	.702	.783
May	2,840	875	1,590	.479	.552
June	2,310	745	1,395	.421	.470
July	1,250	380	874	.263	.303
August	359	213	265	.080	.092
September	640	220	358	.108	.120
October	292	189	233	.070	.081
November	292	160	219	.066	.074

[a] April 15 to 17 discharge estimated.

CEDAR RIVER AT CEDAR RAPIDS, IOWA.

This station was established October 26, 1902, by K. C. Kastberg, assisted by J. C. Stevens. It is located near the city gas works and near the plant of the Iowa Windmill and Pump Company. The gage is an inclined 4 by 6 inch timber, graduated to read to vertical tenths and half-tenths feet. It is fastened to the right bank by posts set in the ground. It is read twice each day by R. S. Toogood. Discharge measurements were made during 1903 from a cable and car at a point just above the gage. The points of measurement are marked by a tag wire. Discharge measurements have been made since 1903 at the First Avenue Bridge about one-half mile upstream from the gage. At low stages the discharge can be measured by wading at the cable. The initial point for soundings at the cable is the foot of the pole supporting the cable on the right bank of the river. The channel is straight for 800 feet above and below the cable. The right bank is high and will overflow only at extreme stages. The left bank is an earth embankment and will seldom overflow. The bed of the stream is rocky and permanent. At the cable the cross section is regular and the channel is about 400 feet wide. Bench mark No. 1 is a city bench mark at Williams & Huntings office, on the north corner of Fifth avenue and West First street. It is marked by a triangle on the stone just north of the first iron post from the corner of the building. Its elevation above sea level, as determined by the city of Cedar Rapids from levels of the Northwestern Railway, is 746.6 feet. Its elevation above the zero of the gage is 23.57 feet. Bench mark No. 2 is a bolt driven into the masonry foundation of the east face of the Iowa Windmill and Pump Company's building on the west bank of the river just north of Seventh avenue. Its elevation is 740.05 feet above sea level and 17.02 feet above the zero of the gage. At the First Avenue Bridge the channel has a rock and gravel bottom and a straight course, both above and below, for several hundred feet. It is divided into five parts by the 5-span Pratt truss bridge, its length from abutment to abutment being 714 feet. The current is strong and direct. The initial point for soundings is the inner upstream face of the left abutment, the measurements being taken from the upstream side of the bridge. The channel is straight for 500 feet above and 1,000 feet below. The banks are high and not liable to overflow. The bed is rock and gravel and permanent. The water flows in five channels. For the purpose of comparing soundings, the distance of the water surface below the top surface of the downstream hand rail at 1 foot west of the nineteenth hand-rail post from the left abutment is measured.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements[a] of Cedar River at Cedar Rapids, Iowa, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
January 14[b]	F. W. Hanna	542	893	1.06	3.60	948
March 15[b]	do	607	1,767	1.92	4.60	3,395
April 19	do	603	1,431	2.94	4.25	4,207
May 26	Johnson and Hanna	577	1,183	1.75	3.50	2,068
June 7	F. W. Hanna	616	1,718	2.62	4.35	4,510
July 11	do	574	1,267	1.84	3.65	2,336
August 17	do	544	893	1.16	3.00	1,040
September 7	do	571	948	1.03	3.13	1,239
October 22	do	497	674	1.57	3.00	1,056
November 12	do	529	811	1.08	2.90	875

[a] All measurements made from bridge. [b] Partially frozen.

Mean daily gage height, in feet, of Cedar River at Cedar Rapids, Iowa, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[b]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[c]
1	3.7	3.7	4.7	4.6	4.1	4.4	3.7	3.1	2.9	2.75	2.9	2.65
2	3.8	3.7	4.75	4.4	4.0	4.15	3.6	3.05	2.95	2.75	2.95	2.7
3	3.9	3.6	4.7	4.3	3.9	4.05	3.5	3.1	3.0	2.75	2.95	2.6
4	3.8	3.6	4.7	4.2	3.85	3.9	3.55	3.1	3.1	2.7	2.95	2.6
5	3.8	3.8	4.6	4.1	3.8	4.1	3.6	3.1	3.15	2.8	2.95	2.65
6	3.7	4.6	4.65	4.05	3.7	4.3	3.55	3.1	3.1	2.8	2.95	2.65
7	3.6	5.4	4.6	4.0	3.7	4.4	3.55	3.1	3.1	2.75	2.9	2.6
8	3.7	4.6	4.55	4.15	3.8	4.55	3.6	3.05	3.1	2.7	2.95	2.6
9	3.6	4.0	4.5	4.3	3.75	4.75	3.6	3.1	3.05	2.85	2.9	2.65
10	3.6	3.8	4.45	4.4	3.8	4.7	3.6	3.1	3.0	2.9	2.9	2.7
11	3.5	3.9	4.45	4.5	3.75	4.55	3.65	3.05	3.0	2.85	2.9	2.65
12	3.4	4.0	4.55	4.9	3.8	4.3	3.6	3.05	2.95	2.9	2.9	2.65
13	3.5	3.9	4.55	5.1	3.8	4.15	3.6	3.0	2.9	2.95	2.85	2.7
14	3.6	3.8	4.65	5.1	3.85	4.0	3.65	3.0	2.9	2.95	2.9	2.7
15	3.5	3.7	4.6	5.0	3.7	3.85	3.7	2.95	2.9	2.95	2.9	2.65
16	3.5	3.8	4.45	4.8	3.65	3.75	3.65	2.9	2.9	2.95	2.85	2.65
17	3.6	3.7	4.55	4.5	3.6	3.7	3.6	3.0	3.0	2.95	2.85	2.7
18	3.7	3.6	4.4	4.4	3.55	3.6	3.55	2.95	2.95	2.95	2.95	2.75
19	3.7	3.7	4.5	4.25	3.5	3.65	3.5	3.0	2.9	3.0	2.9	2.75
20	3.6	3.8	4.7	4.15	3.45	3.55	3.4	2.95	2.9	3.0	2.85	2.8
21	3.5	3.8	4.9	4.2	3.45	3.5	3.4	2.95	2.85	3.0	2.8	2.8
22	3.6	3.7	5.5	4.5	3.4	4.1	3.35	3.0	2.85	2.95	2.75	2.75
23	3.6	3.7	5.45	3.95	3.4	4.2	3.35	2.95	2.8	2.95	2.8	2.8
24	3.5	3.8	5.2	4.0	3.35	4.2	3.3	2.9	2.8	2.95	2.8	2.75
25	3.5	3.8	5.9	.....	3.3	4.0	3.25	2.9	2.85	3.0	2.8	2.75
26	3.6	3.7	6.4	4.5	3.55	3.9	3.4	2.85	2.9	3.0	2.75	2.75
27	3.6	3.8	6.1	4.5	4.4	3.85	3.2	2.9	2.85	3.0	2.7	2.8
28	3.7	3.7	5.65	4.4	4.98	3.75	3.15	2.85	2.85	3.0	2.7	.....
29	3.7	4.7	5.1	4.3	5.55	3.75	3.1	3.0	2.8	3.0	2.7	4.3
30	3.8	.....	4.9	4.2	5.1	3.70	3.15	2.95	2.75	3.0	2.65	.....
31	3.7	.....	4.75	.....	4.65	.....	3.1	2.95	.....	2.95	.....	3.9

[a] River frozen one-half to two-thirds across, January and February.
[b] River frozen during greater portion of month of March.
[c] River partially frozen December 2-27, inclusive, and wholly frozen December 28-31.

NOTE.—Gage heights are to water surface during frozen period.

Rating table for Cedar River at Cedar Rapids, Iowa, from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.65	600	3.50	1,990	4.70	5,690	5.90	10,130
2.70	650	3.60	2,210	4.80	6,060	6.00	10,500
2.75	705	3.70	2,440	4.90	6,430	6.20	11,240
2.80	765	3.80	2,690	5.00	6,800	6.40	11,980
2.85	830	3.90	2,960	5.10	7,170	6.60	12,720
2.90	900	4.00	3,250	5.20	7,540	6.80	13,460
2.95	975	4.10	3,560	5.30	7,910	7.00	14,200
3.00	1,050	4.20	3,880	5.40	8,280	7.20	14,940
3.10	1,210	4.30	4,220	5.50	8,650	7.40	15,680
3.20	1,390	4.40	4,580	5.60	9,020	7.60	16,420
3.30	1,580	4.50	4,950	5.70	9,390	7.80	17,160
3.40	1,780	4.60	5,320	5.80	9,760	8.00	17,900

The above table is applicable only for open-channel conditions. It is based upon 22 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 3 feet and 7.20 feet. The table has been extended beyond these limits. Above gage height 4.4 feet the rating curve is a tangent, the difference being 370 per tenth.

Estimated monthly discharge of Cedar River at Cedar Rapids, Iowa, for 1904.

[Drainage area, 6,317 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April	7,170	3,105	4,614	0.730	0.814
May	8,835	1,580	3,079	.487	.562
June	5,875	1,990	3,481	.551	.615
July	2,440	1,210	1,938	.307	.354
August	1,210	830	1,051	.166	.191
September	1,300	705	958	.152	.170
October	1,050	650	913	.145	.167
November	975	600	842	.133	.148

DES MOINES RIVER DRAINAGE BASIN.

Des Moines River rises in the southern part of Minnesota and flows south and southeast, entering the Mississippi near Keokuk, Iowa. Its principal tributary is Raccoon River, which enters the Des Moines at the city of Des Moines. Des Moines River is the largest river of Iowa, and affords numerous good opportunities for the development of water power. As it drains a large area, it is a natural recipient of the sewage of many towns. The United States Geological Survey maintained stations for a short time at Des Moines on Des Moines and Raccoon rivers. These were after a time discontinued and a permanent station was established at Keosauqua, Iowa. The total drainage area of Des Moines River is 14,720 square miles. Its drainage above the mouth of Raccoon River is 6,462 square miles, while that of the Raccoon at its confluence with the Des Moines is 3,677 square miles.

During 1904 stations were maintained in Des Moines River drainage basin on Des Moines River at Keosauqua, Iowa.

DES MOINES RIVER AT KEOSAUQUA, IOWA.

This station was established May 30, 1903, by F. W. Hanna. It is located at the county bridge one-fourth mile above the old dam site and Government locks. The standard chain gage has the zero of its scale 1 foot to the left of the sixth strut from the right end of the second span from the right end of the bridge. The length of the chain from the end of the weight to the marker is 36.80 feet. The gage is read twice each day by Oscar McCrary. Discharge measurements are made from the downstream side of the four-span bowstring truss bridge, to which the gage is attached. The initial point for soundings is marked zero on the hand rail at the left bank. This is the edge of the west abutment. The channel is straight for 1,000 feet above and below the station and has a width between abutments of 614 feet, broken by three piers. The right bank is high and rocky and is not subject to overflow; the low alluvial bank on the left side is subject to overflow at extremely high stages. The bed of the stream is regular in shape and is composed of sand and gravel on the left and of rock on the right side, and is divided into four channels by the bridge piers. A slight shifting of the sand occurs at flood stages. Bench mark No. 1 is a cross on the bridge-seat stone at the northeast corner of the right abutment of the bridge. Its elevation above gage datum is 30.11 feet, and above sea level is 617.06 feet, as determined from the Iowa Geological Survey bench mark in front of the Keosauqua railroad station. Bench mark No. 2 is located on a rock cliff on the right bank of the river south of the road leading across the highway bridge and at a distance of 120 feet from the east end of

the bridge. It consists of a notch chiseled into the ledge of rock. Its elevation above gage datum is 36.25 feet. Bench mark No. 3 is located on the top of the guard rail, 2 feet east of the zero of the gage. Its elevation is 36.60 feet above gage datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Des Moines River at Keosauqua, Iowa, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
January 13[a]	F. W Hanna	549	919	0.83	0.12	766
March 18	do	567	1,809	1.62	1.75	2,954
April 22	do	586	2,892	2.69	3.55	7,803
May 28	Johnson and Hanna	586	2,632	2.65	3.14	6,979
June 9	F. W. Hanna	590	4,006	3.44	5.25	13,760
July 14	do	571	2,039	1.95	2.10	3,952
August 18	do	567	1,531	1.20	1.26	1,842
September 8	do	528	1,665	1.50	1.60	2,497
October 20	E. Johnson, jr	556	1,453	.66	.85	965
November 15	F. W. Hanna	556	1,270	.65	.79	825

[a] River frozen.

Mean daily gage height, in feet, of Des Moines River at Keosauqua, Iowa, for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	.....	1.5	2.83	6.45	3.78	2.25	1.78	1.32	2.07	0.87	[b] 0.90
2	1.2	2.1	.....	2.68	5.55	4.03	2.35	1.55	1.77	1.65	.87	1.45
3	.....	(c)	.....	2.63	4.90	3.73	2.30	1.48	1.67	1.32	.87	1.30
4	.....	.....	.....	2.43	4.40	4.58	2.12	1.52	1.72	1.14	.79	[b] .82
5	[d] 1.2	.....	[e] 2.2	2.28	4.05	5.53	2.20	1.42	1.69	1.07	.77	.80
6	.....	[c] 3.8	(c)	2.25	3.80	5.90	2.70	1.38	1.82	1.07	.74	.70
7	.....	[c] 6.6	3.0	2.13	3.55	5.85	2.62	1.30	1.77	.99	.74	.70
8	.....	5.9	[f] 2.46	2.38	3.60	5.70	2.75	1.25	1.62	.99	.74	.65
9	[g] 1.15	5.9	2.96	6.88	3.55	5.20	2.58	1.20	1.45	.99	.74	.65
10	.....	.....	1.96	6.43	3.35	4.55	2.45	1.18	1.32	.95	.74	.60
11	.....	.....	1.56	5.73	3.15	4.15	2.40	1.13	1.28	.89	.69	.62
12	.....	[c] 5.7	1.76	6.28	3.10	3.82	2.15	1.30	1.20	.89	.64	[h] .75
13	[i] 1.15	.....	1.56	6.28	3.20	3.50	2.08	1.70	1.63	.87	.64	.65
14	.....	.....	1.16	5.43	3.15	3.20	2.05	1.72	1.25	.87	.64	[j] .60
15	.....	[e] 2.7	1.56	5.38	3.20	2.95	2.00	1.55	1.10	.87	.74	.60
16	[i] 1.15	.....	1.46	5.13	3.15	2.75	2.00	1.40	1.10	.82	.80	.60
17	.....	.....	1.46	4.93	3.15	2.45	1.95	1.32	1.02	.87	.75	.60

[a] Ice 1 foot thick.
[b] Frozen two-thirds of way across.
[c] Ice 0.8 foot thick.
[d] Ice 1.1 feet thick.
[e] Ice 0.9 foot thick.
[f] Ice broken up.
[g] Ice 1.25 feet thick.
[h] River frozen over.
[i] Ice 1.2 feet thick.
[j] Ice 3 inches thick.

Mean daily gage height, in feet, of Des Moines River at Keosauqua, Iowa, for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
18	.....	[a] 2.3	1.79	4.58	2.80	3.15	1.75	1.30	1.00	0.87	0.75	.....
19	.....	.....	3.60	4.33	2.65	2.70	1.65	1.35	1.50	.79	.75	.....
20	[b] 4.55	.....	3.45	4.03	2.50	2.25	2.35	1.50	1.35	.77	.75	.....
21	[c] 5.90	.....	2.80	3.73	2.40	2.30	6.70	1.42	1.20	.80	.70	.....
22	3.30	1.7	2.85	3.53	2.40	2.12	8.08	1.62	1.35	.80	.70	.....
23	2.40	.....	2.80	3.35	2.25	2.25	6.55	1.60	1.25	.83	.70	.....
24	2.00	.....	2.90	3.35	2.20	2.00	4.65	1.45	1.25	.88	.70	[d] 0.60
25	2.40	.....	7.35	[e] 10.95	2.10	2.38	3.28	1.42	1.15	1.00	.70	.....
26	[f] 3.1	.....	6.55	13.15	2.00	2.15	2.57	1.35	1.20	1.00	.70	.....
27	(*g*)	[a] 1.5	4.35	13.15	2.35	2.10	2.25	1.20	5.10	1.00	.70	.....
28	.....	[a] 1.5	3.95	12.45	3.30	2.23	2.05	1.15	6.60	.92	.70	.....
29	.....	1.5	3.38	12.15	4.00	2.50	1.85	1.18	3.15	.87	.70	.....
30	2.5	.....	2.95	9.90	4.30	2.40	1.70	1.15	2.45	.87	.72	.....
31	(*h*)	.....	2.95	.....	3.80	.....	2.22	1.20	.....	.84	.....	[i] .70

[a] Ice 0.9 foot thick.
[b] Ice 1.2 feet thick.
[c] Ice broken up.
[d] Ice thawed out.
[e] Heavy rain.
[f] River frozen over.
[g] Ice 0.4 foot thick.
[h] Ice 0.7 foot thick.
[i] Ice 4 inches thick.

NOTE.—Gage heights during frozen period to surface of water.

Rating table for Des Moines River at Keosauqua, Iowa, from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	420	1.70	2,800	2.9	5,920	4.1	9,840
.60	590	1.80	3,030	3.0	6,220	4.2	10,200
.70	770	1.90	3,260	3.1	6,520	4.3	10,560
.80	950	2.00	3,500	3.2	6,830	4.4	10,930
.90	1,140	2.10	3,750	3.3	7,150	4.5	11,300
1.00	1,330	2.20	4,000	3.4	7,470	4.6	11,670
1.10	1,530	2.30	4,260	3.5	7,800	4.7	12,040
1.20	1,730	2.40	4,520	3.6	8,130	4.8	12,410
1.30	1,940	2.5	4,780	3.7	8,460	5.0	13,150
1.40	2,150	2.6	5,060	3.8	8,800		
1.50	2,360	2.7	5,340	3.9	9,140		
1.60	2,580	2.8	5,630	4.0	9,490		

The above table is applicable only for open-channel conditions. It is based upon 19 discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.8 foot and 5.2 feet. There are two flood measurements above 5.2 feet gage height. The table has been extended beyond these limits. Above gage height 4.30 feet the rating curve is a tangent, the difference being 370 per tenth. Table same as for 1903 above 2.4 feet gage.

Estimated monthly discharge of Des Moines River at Keosauqua, Iowa, for 1904.

[Drainage area, 14,290 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 9–31	21,840	1,650	6,441	0.451	0.386
April	43,300	3,825	15,990	1.12	1.25
May	18,520	3,500	7,566	.529	.610
June	16,480	3,500	7,817	.547	.610
July	24,550	2,800	6,026	.422	.486
August	2,984	1,590	2,132	.149	.172
September	19,070	1,330	3,305	.231	.258
October	3,675	896	1,318	.092	.106
November	1,078	662	833	.058	.065

MISSOURI RIVER DRAINAGE BASIN.

Missouri River is formed by the junction of Jefferson, Madison, and Gallatin rivers at Three Forks, Mont. Of its tributaries, Osage River rises in the eastern part of Kansas, flows east, and enters the Missouri below Jefferson City, Mo. Big Sioux River drains the extreme eastern part of South Dakota and flows south into the Missouri at Sioux City, Iowa. Niobrara River drains the extreme northern part of Nebraska and flows east into the Missouri at Niobrara, Nebr. Yellowstone River has its source in a lake of the same name in Yellowstone National Park, from which it takes a general northeasterly course and flows into the Missouri near the Montana-North Dakota boundary. Its principal tributaries are Powder River, of which Clear Creek and Piney Creek, in Wyoming, are small tributaries near its headwaters, and the Bighorn, which drains northeastern Wyoming and of which the Shoshone is a tributary. Milk River rises on the divide in the northwestern part of Montana, flows northeast into Canada, and then, with a general easterly course, flows back into Montana, emptying into the Missouri in the northeastern part of the State. Musselshell River rises in Meagher County, in south-central Montana, flows east, then north into the Missouri, about 100 miles above the mouth of Milk River. Marias, Teton, and Sun rivers rise on the divide in the northwestern part of Montana and flow east into the Missouri. Two Medicine Creek is a tributary near its headwaters. West Gallatin River, the longest fork of the Gallatin, rises in Yellowstone Park and flows north to its junction at Three Forks, Mont., with Madison and Jefferson rivers. Middle Creek is a small tributary of East Gallatin River. Madison River

rises in Yellowstone Park and flows north parallel to the West Gallatin. Pryor Creek is a small tributary of the Yellowstone rising on the Crow Reservation, Mont. Jefferson River is formed by Beaverhead and Big Hole rivers. Its tributaries drain extreme southwestern Montana. Gasconade River rises in the Ozark Mountains in southern Missouri and flows northeasterly into Missouri River; it has excellent water-power facilities; its total drainage area is 3,466 square miles, and its drainage area at Arlington is 2,725 square miles.

MISSOURI RIVER NEAR TOWNSEND, MONT.

This station was established October 1, 1891, by the Missouri River Commission. The locality is 2,504 miles above the mouth of the river. A standard wire cable gage was erected on a county-road bridge located about 300 feet below the Northern Pacific Railway bridge across Missouri River near Townsend, Mont. Its zero is set at an approximate elevation of 3,700 feet above sea level, as determined from a primary line of levels run under the direction of the Commission in 1890 from Three Forks to Fort Benton, Mont., and starting from a bench mark of the Northern Pacific Railway at Gallatin, Mont. (See Annual Report of Chief of Engineers, 1891.)

The gage reads from 3,785 to 3,799 feet. A record of the daily gage height is maintained by the Department of Agriculture. The observer for both Departments is M. McMahon. A gage reading of 3,785 feet is taken as the zero of the United States Geological Survey observations. Discharge measurements are made from the lower side of the bridge, and distances are marked on the guard rail. The initial point for soundings is over the left pier on the lower side and is marked on the guard rail. The channel is straight for 300 feet above and below the station. The right bank is low, but has been known to be overflowed but once. The left bank is high and rocky. The bed of the stream is composed of clean gravel and is shifting. The channel is broken by three bridge piers, and the velocity is made uncertain by eddies and backwater. The piers are protected on the upstream side by heaps of riprap and by cofferdams. These cause an appreciable difference in the elevation of the water surface above and below these protections. They cause a contraction of the current, which has eroded large holes under the bridge.

The United States engineers' reference bench mark is B. M. 10 (Townsend), described as "located on the right bank of Missouri River, about one-half mile north of Townsend railroad station, about one-half mile from river, measured in a perpendicular direction to track, and about three-fourths mile south of the railroad bridge over Missouri River. It is about 60 feet west of a point on the track 30 feet north of railroad bridge No. 392, and about 7 feet west of railroad fence. Compass reading to milepost 1121 is 318°. Marked by

stone and pipe; elevation, 3,795.991 feet." This elevation is erroneous, but is the elevation from which the gage is set.

The tabulated records of the Townsend gage are reductions to the St. Louis directrix datum obtained by subtracting 400.063 feet from the daily means of the gage readings. In April, 1903, two new bench marks were established by J. S. Baker. The first has been destroyed. The second of these bench marks is a spike driven near the ground in the north side of a 12 by 12 inch post located on the north bank of the river about 200 feet below the bridge. Its elevation is 14.98 feet above the Geological Survey gage datum. A third bench mark was established April, 1904, by A. E. Place. It is marked by a chiseled cross on the southeast corner of the northeast bedplate of the north abutment of the railroad bridge, 300 feet west of the station. Its elevation is 24.614 above the zero of the gage. The area drained at this point is approximately 15,000 square miles, comprising, as above stated, the inflow from Gallatin, Madison, and Jefferson rivers. This gage at Townsend is the highest of a series of twenty or more gages maintained permanently by the Missouri River Commission. Descriptions of these gages are given in the annual report of the Missouri River Commission, contained in the Annual Report of the Chief of Engineers, United States Army; that for 1891, on page 3819; for 1892, on page 3271, and for 1893, on page 2316. The distance of this point above Sioux City is 1,703 miles, and above Fort Benton, the next gage below maintained by the Corps of Engineers, 219 miles. The station was abandoned May 31, 1904, on account of the obstructions and irregularities of the channel caused by the reconstruction of the Northern Pacific Railway bridge above the station. The gaging stations on Gallatin River at Logan, Mont., on Jefferson River at Sappington, Mont., and on Madison River at Norris, Mont., will cover all tributaries to the Missouri above the station with the exception of Sixteen Mile Creek, which enters at Lombard, Mont., and a few short creeks of minor importance. Between Townsend and Cascade, the next gaging station below, there is but one large tributary, Prickly Pear Creek. The headwaters of Missouri River can therefore be sufficiently measured without maintaining the Townsend station.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Missouri River near Townsend, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 15	A. E. Place	431	2,145	3.45	5.12	7,419
May 24	W. B. Freeman	404	3,475	6.45	7.89	22,405

Mean daily gage height, in feet, of Missouri River near Townsend, Mont., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.
1	6.10	5.60	6.00	4.20	6.40	17	5.60	5.60	4.10	5.10	6.30
2	6.10	5.60	6.30	4.10	6.20	18	5.60	5.60	4.10	5.00	6.30
3	6.10	5.60	6.40	4.20	6.10	19	5.60	5.70	4.10	5.00	6.40
4	6.10	5.60	6.50	4.30	6.30	20	5.60	5.70	4.10	5.20	6.60
5	6.10	5.60	6.60	4.50	6.50	21	5.60	5.70	4.20	5.40	6.90
6	6.10	5.60	6.80	4.50	6.60	22	5.70	5.70	4.10	5.60	7.10
7	6.10	5.60	6.90	4.40	6.30	23	5.60	5.70	4.10	5.70	7.40
8	6.10	5.60	7.00	4.30	6.30	24	5.60	5.70	4.00	5.60	7.90
9	6.10	5.60	7.00	4.30	6.20	25	5.60	5.70	3.60	5.70	8.40
10	5.60	5.60	7.00	4.40	5.90	26	5.60	5.70	3.70	5.90	8.40
11	5.60	5.60	7.00	4.50	5.90	27	5.60	5.70	3.90	5.70	8.10
12	5.60	5.60	7.00	4.90	6.00	28	5.60	5.80	4.10	5.90	7.90
13	5.60	5.60	7.00	4.90	6.10	29	5.60	5.90	4.20	6.20	7.50
14	5.60	5.60	7.00	5.00	5.90	30	5.60	.....	4.30	6.50	7.20
15	5.60	5.60	4.50	5.10	6.10	31	5.60	.....	4.30	.....	7.50
16	5.60	5.60	[a]4.20	5.10	6.20						

[a] Gage heights do not represent normal flow till March 16 on account of ice conditions. Station abandoned May 31.

Rating table for Missouri River near Townsend, Mont., from January 1, 1901, to May 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	1,200	4.20	4,270	5.40	8,555	7.20	17,040
3.10	1,390	4.30	4,600	5.50	8,965	7.40	18,210
3.20	1,590	4.40	4,930	5.60	9,375	7.60	19,450
3.30	1,800	4.50	5,260	5.70	9,795	7.80	20,760
3.40	2,020	4.60	5,600	5.80	10,220	8.00	22,150
3.50	2,250	4.70	5,940	5.90	10,655	8.20	23,650
3.60	2,490	4.80	6,285	6.00	11,100	8.40	25,410
3.70	2,745	4.90	6,635	6.20	12,015	8.60	27,490
3.80	3,020	5.00	7,000	6.40	12,960	8.80	29,830
3.90	3,315	5.10	7,375	6.60	13,930		
4.00	3,630	5.20	7,760	6.80	14,925		
4.10	3,950	5.30	8,155	7.00	15,950		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1901–1904. It is well defined between gage heights 3.3 feet and 8.5 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Missouri River near Townsend, Mont., for 1904.

[Drainage area, 14,500 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a] 2,700	166,016	0.186	0.214
February	.....	.....	[a] 2,700	155,306	.186	.201
March 15–31, inclusive	5,260	2,490	[b] 3,947	242,692	.272	.314
April	13,440	3,950	7,318	435,451	.505	.563
May	25,410	10,655	14,672	902,146	1.012	1.167

[a] Estimated by C. C. Babb. [b] Mean for 17 days taken as mean for entire month.

MISSOURI RIVER AT CASCADE, MONT.

This station was established July 20, 1902, by W. W. Schlecht. It is located at the highway bridge at the east end of the town of Cascade, Mont., about one-fourth mile from the railroad. There is an island about 600 feet above the station and one about 300 feet below. There is a fall of about 1 foot at the island below the station. The wire gage first installed has been replaced by a standard chain gage, which is located on the upstream side of the left span, and is fastened to the floor of the bridge. The distance from the end of the weight to the marker should be 31.97 feet. The marker is the outside of the ring which serves as a handle. The gage is read twice each day by H. W. Ludwig. Discharge measurements are made from the upstream side of the bridge. The central pier of this bridge is protected by an ice and drift breaker, which extends about 125 feet upstream. The initial point for soundings is notched on the guard rail 2.5 feet to the left of center of the southeast bridge pier. The channel is straight for about 600 feet above and 200 feet below the station. The right bank is low and the left bank is high, with bushes along both banks. The single channel is only broken by the bridge piers. The ice breaker affects the current to some extent. Two bench marks were established in April, 1904. Bench mark No. 1 is the top of an old iron bolt on the southwest iron bridge pier, which secures the bed plates. It is painted in black "U. S. G. S. B. M.," and has an elevation of 28.54 feet above the gage datum. Bench mark No. 2 is a standard bench mark of the Missouri River Commission, situated 200 feet east of the Great Northern Railway station. Its elevation above the gage zero is 36.58 feet.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Missouri River at Cascade, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 13	A. E. Place	373	3,060	2.19	5.52	6,714
May 28	L. R. Stockman	489	4,823	4.77	9.40	23,026
June 3	Murphy and Freeman	466	4,767	4.29	9.24	20,437
June 11	W. B. Freeman	466	4,393	4.09	8.45	17,753
July 27	do	356	2,929	1.90	5.15	5,552
August 16	do	342	2,447	1.05	3.90	2,571
September 12	do	348	2,381	.95	3.80	2,255
November 10	L. R. Stockman		2,664	1.43	4.52	3,805

Mean daily gage height, in feet, of Missouri River at Cascade, Mont., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.20	5.50	6.15	5.80	7.35	8.42	6.70	4.40	3.80	3.95	4.45	4.45
2	5.30	5.50	6.20	5.80	7.25	8.62	6.55	4.40	3.75	3.95	4.40	4.45
3	5.30	5.50	6.20	5.50	7.18	9.05	6.38	4.40	3.70	4.00	4.40	4.50
4	5.45	5.50	6.20	5.30	7.10	9.20	6.30	4.40	3.65	4.00	4.35	4.53
5	5.50	5.60	6.25	5.30	7.12	9.20	6.12	4.40	3.60	4.00	4.35	4.55
6	5.50	5.60	6.25	5.25	7.28	9.08	5.98	4.40	3.55	4.00	4.33	4.60
7	5.40	5.70	6.25	5.15	7.38	8.92	5.88	4.40	3.55	4.00	4.35	4.50
8	5.40	5.70	6.20	5.05	7.30	8.80	5.80	4.40	3.60	4.00	4.40	4.40
9	5.40	5.70	6.20	5.00	7.28	8.70	5.80	4.45	3.65	4.02	4.40	4.30
10	5.50	5.70	6.20	5.10	7.18	8.70	5.85	4.45	3.70	4.05	4.40	4.20
11	5.50	5.80	6.10	5.20	7.05	8.55	5.92	4.40	3.80	4.10	4.40	4.10
12	5.50	5.80	6.10	5.30	6.90	8.50	5.88	4.40	3.80	4.12	4.40	4.10
13	5.50	5.80	6.10	5.50	6.90	8.45	5.80	4.40	3.80	4.18	4.40	4.20
14	5.50	5.80	6.10	5.90	6.90	8.28	5.75	4.25	3.80	4.20	4.40	4.20
15	5.50	5.90	6.00	6.00	6.90	8.10	5.72	4.05	3.80	4.25	4.40	4.25
16	5.50	5.90	6.00	6.15	6.90	7.98	5.70	3.95	3.80	4.25	4.40	4.25
17	5.50	5.90	6.00	6.05	6.90	7.88	5.62	4.00	3.80	4.25	4.40	4.30
18	5.50	6.00	6.00	5.95	6.95	7.78	5.52	4.00	3.80	4.30	4.40	4.30
19	5.50	6.00	6.00	6.00	7.10	7.88	5.42	4.00	3.80	4.30	4.40	4.35
20	5.40	6.10	5.90	5.98	7.25	8.00	5.52	4.00	3.80	4.30	4.50	4.50
21	5.40	6.10	5.90	6.08	7.48	8.08	5.50	4.00	3.80	4.30	4.50	4.55
22	5.40	6.20	5.90	6.25	8.00	7.95	5.55	4.00	3.75	4.30	4.50	4.70
23	5.40	6.20	5.80	6.48	8.30	7.75	5.50	4.00	3.75	4.30	4.50	4.70
24	5.40	6.20	5.80	6.52	8.60	7.62	5.42	4.00	3.75	4.35	4.50	4.80
25	5.40	6.10	5.80	6.50	8.88	7.52	5.32	4.00	3.75	4.35	4.50	[b]4.85
26	5.50	6.10	5.70	6.55	9.30	7.35	5.28	4.00	3.80	4.40	4.50	4.90
27	5.50	6.10	5.70	6.62	9.50	7.18	5.15	4.00	3.80	4.42	4.40	4.80
28	5.50	6.15	5.70	6.75	9.32	6.95	4.95	3.98	3.85	4.45	4.40	4.80
29	5.50	6.15	5.70	6.88	9.02	6.80	4.75	3.92	3.85	4.50	4.40	4.70
30	5.50	.....	5.70	7.08	8.62	6.72	4.55	3.90	3.90	4.50	4.45	4.70
31	5.50	.....	5.70	.....	8.38	.....	4.50	3.85	.....	4.50	.....	4.60

[a] River frozen January 1 to April 1. Readngs to top of ice. Ice 12 to 15 inches thick.
[b] River frozen December 25 to 31.

Rating table for Missouri River at Cascade, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.60	1,970	4.70	4,170	5.80	8,020	7.80	15,420
3.70	2,090	4.80	4,490	5.90	8,390	8.00	16,160
3.80	2,230	4.90	4,810	6.00	8,760	8.20	16,900
3.90	2,380	5.00	5,150	6.20	9,500	8.40	17,640
4.00	2,550	5.10	5,490	6.40	10,240	8.60	18,380
4.10	2,740	5.20	5,830	6.60	10,980	8.80	19,120
4.20	2,940	5.30	6,190	6.80	11,720	9.00	19,860
4.30	3,150	5.40	6,550	7.00	12,460	9.20	20,600
4.40	3,370	5.50	6,910	7.20	13,200	9.40	21,340
4.50	3,600	5.60	7,280	7.40	13,940		
4.60	3,870	5.70	7,650	7.60	14,680		

The above table is applicable only for open-channel conditions. It is based upon 16 discharge measurements made during 1902–1904. It is fairly well defined between gage heights 3.6 and 9.4 feet. Above gage height 5.5 feet the rating curve is a tangent, the difference being 370 per tenth.

Estimated monthly discharge of Missouri River at Cascade, Mont., for 1904.

[Drainage area, 18,295 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a] 6,000	368,926	0.328	0.378
February	.....	.....	[a] 6,000	345,124	.328	.354
March	.....	.....	[a] 6,000	368,926	.328	.378
April	12,830	5,150	8,409	500,370	.460	.513
May	21,710	12,090	14,925	917,702	.816	.941
June	20,600	11,350	16,660	991,339	.911	1.016
July	11,350	3,600	7,436	457,222	.406	.468
August	3,480	2,305	2,898	178,191	.158	.182
September	2,380	1,915	2,167	128,946	.118	.132
October	3,600	2,465	2,979	183,172	.163	.188
November	3,600	3,260	3,416	203,266	.187	.209
December	4,490	2,740	3,597	221,171	.197	.227
The year	.....	.....	6,707	4,864,355	.367	4.986

[a] Estimated.

MISSOURI RIVER AT MANNHAVEN, N. DAK.

This station was established October 25, 1904, by E. F. Chandler. It is located at Mannhaven, N. Dak., a town on the west side of Missouri River about 50 miles north of New Salem, on the Northern Pacific Railway, and 18 miles west of Underwood, on the Minneapolis, St. Paul and Sault Ste. Marie Railway. The gage, consisting of three sections made of 2 by 4 inch timbers, reading to tenths of feet, is installed on the right bank of the river behind the lumber office of John Netzer, the observer. Measurements are made by means of a small gasoline ferryboat which is rented for each measurement. The initial point for soundings is the face of the perpendicular bank under Lyon's elevator on the right side of the stream, and the distances for the soundings are obtained by means of stadia sights taken from the boat on the rods placed on each shore. The channel at low-water stages is about 1,450 feet wide and is straight for about 2 miles above and one-half mile below the station. The current has a medium velocity at ordinary stages. The right bank is a high cliff. The left bank is low, sandy, and wooded and is subject to overflow at high stages. The bed of the stream is sandy and shifting.

The observations at this station during 1904 were under the direction of E. Johnson, jr., district hydrographer.

Discharge measurement of Missouri River at Mannhaven, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
October 25	E. F. Chandler	800	4,840	2.95	3.11	14,270

Mean daily gage height, in feet, of Missouri River at Mannhaven, N. Dak., for 1904.

Day.	Oct.	Nov.	Day.	Oct.	Nov.	Day.	Oct.	Nov.
1		(a)	12		(a)	23		2.85
2			13		2.90	24		2.82
3		b3.00	14		2.90	25		2.90
4			15		2.85	26	3.10	2.95
5			16		2.85	27		
6			17		2.80	28	3.12	
7			18		2.75	29	3.21	
8		b2.90	19		2.70	30	3.15	
9			20		2.75	31	3.08	
10			21		2.75			
11			22		2.80			

a Gage broken November 1 to 12, inclusive. b Estimated gage height.

MISSOURI RIVER NEAR BISMARCK, N. DAK.

This station was established September 28, 1904, by E. F. Chandler and is located near the town of Bismarck, N. Dak. The gage consists of a braided-wire affair of substantial pattern and is located near the middle of the second span of the Northern Pacific Railway bridge from the left bank. Measurements are made by the means of a cable ferry-boat at "Fort Lincoln" ferry, 5 miles southwest from Bismarck. The initial point for soundings is the face of the perpendicular bank on the right side of the river, and the distances from the initial point are obtained by stadia sights from the boat on rods placed on each shore. The channel is straight for nearly one-half mile both above and below the station. The current has a moderate velocity at ordinary stages. The right bank is high and not subject to overflow. The left bank consists of sandy slopes and wooded bottoms and is overflowed at extreme flood stages. The bed is sandy and subject to considerable shifting. The bench mark is the top of the railway track on the Northern Pacific Railway bridge at the gage and has an elevation of 73.9 feet above the datum of the gage. The gage is read each day by Mrs. Jennie S. Plante.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurement of Missouri River near Bismarck, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
October 28	E. F. Chandler	830	4,859	2.09	0.16	10,350

Mean daily gage height, in feet, of Missouri River near Bismarck, N. Dak., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.[a]	Day.	Sept.	Oct.	Nov.	Dec.[a]
1		0.10	0.20	0.60	17		0.40	0.55	2.05
2		.10	.10	.10	18		.40	.75	2.25
3		.10	.10	.00	19		.30	.90	2.55
4		.20	.10	.50	20		.30	1.00	2.60
5		.30	.10	.90	21		.30	1.00	2.70
6		.50	.10	.90	22		.40	1.00	2.85
7		.50	.10	.80	23		.40	.90	3.00
8		.50	.00	.45	24		.40	.80	3.30
9		.50	.00	.20	25		.20	.80	3.50
10		.50	.00	.10	26		.00	.80	3.50
11		.40	.00	.15	27		.00	.80	3.50
12		.50	.10	.40	28	0.05	.20	.60	3.85
13		.50	.10	.70	29	.10	.20	.18	4.10
14		.40	.10	1.20	30	.10	.20	.10	4.10
15		.40	.10	1.35	31		.20		3.90
16		.40	.15	1.70					

[a] River frozen during December.

MADISON RIVER (INCLUDING CHERRY CREEK) NEAR NORRIS, MONT.

This station is located at the ranch of the observer, Mrs. S. A. Black, 4 miles below the Redbluff County iron bridge over the Madison, and about 1½ miles below the mouth of Cherry Creek. It is also about 3 miles below the location of the old Redbluff station, described in Bulletin No. 131, on page 18. It was established May 2, 1897, at which time the one at Threeforks was discontinued. The vertical gage is fastened to a post set firmly in the bed of the river and braced with crosspieces from the bank. It is about 125 yards west of the observer's house. Discharge measurements are made from the lower side of the iron bridge above. Cherry Creek is measured at the same time, as it enters between the gage and the bridge. The initial point for soundings is at the left abutment of the bridge. The banks are high and do not overflow. The bed of the stream is rocky and the current is quite swift. The channel is curved both above and below the station, but the bridge is at right angles to the current. The bench mark established June 6, 1901, by J. S. Baker, is the top of a large granite bowlder 20 feet south of the gage rod and 8 feet east of the river bank. There is a spot of black paint on the top of the bowlder, and the letters "B. M. U. S. G. S. 6.856." The elevation of this bench mark is 6.856 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Madison River near Norris, Mont., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.	Discharge from Cherry Creek.[a]
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Sec.-feet.*	
April 19	A. E. Place	476	4.18	1.50	1,989	77
May 14	W. B. Freeman	557	4.28	1.91	2,384	80
June 14	do	854	6.51	2.87	5,558	130
July 6	do	623	5.04	2.10	3,140	73
July 19	do	493	4.43	1.78	2,186	20
August 23	W. B. Freeman and Robert Follansbee.	397	3.60	1.48	1,427	13
October 28	L. R. Stockman	404	3.61	1.45	1,459	12

[a] Add discharge of Cherry Creek to that of Madison to get entire amount passing gage.

Mean daily gage height, in feet, of Madison River near Norris, Mont., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1				1.40	1.70	3.00	2.30	1.60	1.48	1.40	1.40	1.40
2				1.40	1.71	3.15	2.30	1.60	1.48	1.40	1.40	
3				1.40	1.77	3.20	2.25	1.60	1.48	1.40	1.40	
4				1.35	1.85	3.20	2.25	1.55	1.40	1.40	1.40	
5				1.30	1.90	2.95	2.25	1.50	1.40	1.40	1.40	
6			1.40	1.30	1.99	2.95	2.20	1.50	1.40	1.40	1.40	
7			1.50	1.30	2.00	2.95	2.15	1.50	1.40	1.40	1.40	
8			1.60	1.30	1.90	2.95	2.10	1.50	1.40	1.40	1.40	
9			1.50	1.30	1.85	3.00	2.00	1.50	1.40	1.40	1.40	
10			1.40	1.45	1.87	3.00	2.00	1.50	1.40	1.40	1.40	
11			1.40	1.45	1.90	3.02	2.00	1.50	1.40	1.40	1.40	
12			1.40	1.45	1.90	3.00	2.05	1.50	1.40	1.40	1.40	
13			1.40	1.45	1.90	2.90	2.00	1.50	1.40	1.40	1.40	
14			1.40	1.45	1.90	2.85	1.90	1.50	1.40	1.40	1.40	
15			1.40	1.40	2.00	2.80	1.90	1.50	1.40	1.40	1.40	
16			1.40	1.40	2.00	2.80	1.85	1.50	1.40	1.40	1.40	
17			1.40	1.45	2.05	2.80	1.85	1.50	1.40	1.45	1.40	
18			1.40	1.50	2.10	2.90	1.80	1.50	1.40	1.45	1.40	
19			1.40	1.55	2.22	3.10	1.80	1.50	1.40	1.45	1.40	
20			1.30	1.55	2.35	2.95	1.75	1.50	1.40	1.45	1.40	
21			1.30	1.52	2.50	2.85	1.75	1.50	1.42	1.45	1.40	
22			1.30	1.50	2.70	2.85	1.75	1.50	1.45	1.45	1.40	
23				1.50	2.90	2.90	1.75	1.50	1.45	1.45	1.40	
24				1.50	3.15	2.76	1.75	1.50	1.45	1.45	1.40	
25				1.50	3.20	2.70	1.72	1.45	1.45	1.45	1.40	
26			1.40	1.50	3.05	2.60	1.70	1.45	1.45	1.45	1.40	
27			1.40	1.55	2.85	2.45	1.70	1.45	1.45	1.45	1.40	
28			1.40	1.60	2.70	2.30	1.70	1.45	1.45	1.45	1.40	
29			1.40	1.70	2.70	2.30	1.71	1.48	1.45	1.45	1.40	
30			1.40	1.70	2.70	2.30	1.72	1.48	1.45	1.40	1.40	
31			1.40		2.90		1.60	1.48		1.40		

[a] River frozen January 1 to March 5, March 23–25, and December 2–31, inclusive.

Rating table for Madison River (including Cherry Creek) near Norris, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.30	1,100	1.80	2,285	2.30	3,855	2.80	5,455
1.35	1,209	1.85	2,430	2.35	4,015	2.85	5,615
1.40	1,300	1.90	2,580	2.40	4,175	2.90	5,775
1.45	1,410	1.95	2,735	2.45	4,335	2.95	5,935
1.50	1,520	2.00	2,895	2.50	4,495	3.00	6,095
1.55	1,635	2.05	3,055	2.55	4,655	3.05	6,255
1.60	1,755	2.10	3,215	2.60	4,815	3.10	6,415
1.65	1,880	2.15	3,375	2.65	4,975	3.15	6,575
1.70	2,010	2.20	3,535	2.70	5,135	3.20	6,735
1.75	2,145	2.25	3,695	2.75	5,295		

The preceding table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is fairly well defined between gage heights 1.50 feet and 2.87 feet. The table has been extended beyond these limits. Above gage height 2.0 feet the rating curve is a tangent, the difference being 320 per tenth.

Estimated monthly discharge of Madison River (including Cherry Creek) near Norris, Mont., for 1904.

[Drainage area, 2,085 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a] 1,200	73,785	0.576	0.664
February	.....	.....	[a] 1,200	69,025	.576	.621
March [b]	1,755	1,100	[c] 1,288	79,196	.618	.712
April	2,010	1,100	1,433	85,269	.687	.766
May	6,735	2,010	3,745	230,271	1.796	2.071
June	6,735	3,855	5,610	333,818	2.691	3.002
July	3,855	1,755	2,667	163,988	1.279	1.475
August	1,755	1,410	1,532	94,199	.735	.847
September	1,520	1,300	1,355	80,628	.650	.725
October	1,410	1,300	1,346	82,762	.646	.745
November	1,300	1,300	1,300	77,355	.624	.696
December	.....	.....	[a] 1,200	73,785	.576	.664
The year	.....	.....	1,990	1,444,081	.954	12.988

[a] Estimated by C. C. Babb.
[b] March 6–31, inclusive. March 23, 24, 25 estimated.
[c] Mean for 26 days taken as mean for month.

WEST GALLATIN RIVER NEAR SALESVILLE, MONT.

The Salesville station, which has been maintained for a number of years, was established near Williams's ranch, about 16 miles southwest of Bozeman. A gage rod was erected in July, 1895, and observations were begun on August 1 by Ira T. Williams, a ranchman, living about 600 feet away. The gage was spiked to a tree. The bench mark consisted of a 6-inch spike driven in the top of a stump 5 feet north of the gage post. It was 6.71 feet above the zero of the gage, as lowered 5 feet from the original position. A second bench mark consisted of a 6-inch spike driven into the east bridge abutment. This was 9.26 feet above the zero of the gage. The initial point for soundings is marked on the guard rail over the rim of the left pier. The highway bridge, from the lower side of which discharge measurements are made, is not at right angles to the current. At flood stages the water flows behind the bridge abutments on the right bank, but at

other times is confined within the channel. The bed of the stream is composed of bowlders and is not liable to change. The velocity is high, rendering discharge measurements somewhat difficult. The channel is nearly straight, with slight curves both above and below. The West Gallatin canal, carrying about 125 second-feet between July 1 and September 15, is taken out below the station. The Kleinschmidt canal, carrying about 50 second-feet between July 1 and August 15, and one or two smaller ditches are taken out above the station. In September, 1896, a wire gage was placed on the bridge, the pulley being fastened to the end of the rod opposite the 0.15-foot mark. The distance from the end of the weight to the index marker is 15.50 feet. On October 15, 1903, this length was 15.70 feet. The two gages were made to read the same. April 20, 1904, a standard chain gage was substituted for the wire gage, maintaining the same datum above the zero of the gage. The new chain length was made 17.38 feet from end of weight to marker, the latter being a wire index near handle. During high water, however, the old rod gage is read, as it stands in less turbulent water. Bench mark No. 1 for the new gage is the head of the most westerly rivet holding the angle irons to the pier of the southeast cylindrical pier. Its elevation is 13.865 feet above the gage datum. Bench mark No. 2, established May 22, 1900, by J. S. Baker, is a large bowlder set firmly in the ground on the south side of the wagon road, near the fence. It is 123 feet east of the center of the southeast cylindrical pier, and is at an elevation of 13.69 feet above the gage datum. The observers were Miss Marguerite Williams and Mrs. Alvin De Long.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of West Gallatin River at Salesville, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 13	W. B. Freeman	98	311	4.10	4.21	1,275
May 31	W. B. Freeman and E. C. Murphy.	143	587	7.68	6.33	4,510
June 13	W. B. Freeman	143	561	7.37	6.16	4,132
July 5	do	136	448	5.79	5.18	2,595
July 18	do	98	325	4.22	4.23	1,371
August 22	W. B. Freeman and Robert Follansbee.	91	221	2.45	3.34	542
October 27	L. R. Stockman	87	221	2.22	3.17	491

Mean daily gage height, in feet, of West Gallatin River at Salesville, Mont., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	2.90	2.60	2.70	4.20	6.75	5.70	3.85	3.25	3.30	3.10	2.90
2	2.80	2.70	2.70	2.80	4.00	6.65	5.50	3.75	.....	3.30	3.10	2.90
3	2.80	[a]2.80	2.60	2.80	4.20	6.45	5.60	3.75	3.25	3.30	3.10	3.00
4	2.90	3.00	2.80	2.90	4.20	6.10	.....	3.75	3.25	3.20	3.00	2.90
5	2.90	3.10	2.70	2.90	4.40	6.00	5.20	3.75	3.25	3.20	3.00	2.90
6	2.90	2.80	2.70	2.80	4.20	6.75	5.20	3.65	3.25	3.20	3.10	2.90
7	2.90	2.70	2.70	2.80	4.20	6.55	5.30	3.55	3.25	3.20	3.10	2.90
8	2.90	2.70	2.80	2.80	4.20	6.15	5.30	3.55	3.15	3.20	3.10	2.90
9	2.90	2.70	2.80	2.80	4.20	6.45	5.20	3.45	3.15	3.20	3.10	2.90
10	[a]2.90	2.80	2.80	2.90	4.30	6.85	5.20	3.55	3.15	3.20	3.10	2.90
11	3.10	2.70	2.80	4.10	4.30	6.75	5.10	3.65	3.15	3.30	3.10	2.90
12	3.10	2.80	2.70	3.40	4.30	6.30	4.80	3.65	3.15	3.30	.....	2.90
13	3.10	2.80	2.70	3.20	4.20	6.15	4.90	3.65	3.25	3.30	3.10	2.90
14	3.05	2.70	2.60	3.00	4.40	6.25	4.90	3.65	3.25	3.30	3.10	2.90
15	3.05	2.70	2.60	3.00	4.60	6.50	4.70	3.55	3.25	3.30	3.10	2.90
16	2.80	2.70	2.70	3.20	4.60	6.55	4.70	3.55	3.15	3.30	3.10	2.90
17	2.80	2.70	2.70	3.20	4.80	6.80	4.50	3.45	3.25	3.20	3.00	2.90
18	2.80	2.70	2.80	3.20	5.30	7.00	4.25	3.45	3.15	3.20	3.00	2.90
19	2.70	2.70	2.70	3.40	5.40	7.15	4.30	3.35	3.15	3.20	3.00	2.90
20	2.70	2.70	2.70	3.80	5.60	6.60	4.30	3.35	3.25	3.20	3.00	2.90
21	2.70	2.70	2.70	3.80	5.80	6.65	4.30	3.35	3.35	3.20	3.00	2.90
22	2.70	2.80	2.70	3.60	6.30	6.35	4.20	3.35	3.35	3.20	3.00	2.80
23	2.70	2.80	2.70	3.40	6.90	6.05	4.30	3.35	3.35	3.20	3.00	2.80
24	2.70	2.80	2.60	3.40	7.20	5.75	4.20	3.25	3.35	3.20	3.10	2.80
25	2.80	2.80	2.60	3.60	6.20	5.65	4.20	3.25	3.35	3.10	3.10	2.80
26	2.80	2.80	2.70	3.80	5.70	5.35	4.20	3.25	3.35	3.10	3.10	2.70
27	2.80	2.80	2.70	4.00	5.30	5.45	4.20	3.15	3.35	3.15	3.10	2.70
28	2.80	2.80	2.70	4.20	5.40	5.50	4.20	3.35	3.35	3.20	3.00	2.80
29	2.90	2.80	2.70	4.00	6.10	5.45	4.10	3.45	3.35	3.10	3.00	2.90
30	2.90	.....	2.70	4.00	5.70	5.55	4.00	3.45	3.35	3.10	3.00	3.00
31	2.90	.....	2.70	.....	6.30	.....	3.90	3.35	.....	3.10	.....	3.00

[a] Ice formed on edges January 10 and February 3, making channel very narrow.

Rating table for West Gallatin River at Salesville, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.60	320	3.60	710	4.60	1,875	5.60	3,375
2.70	335	3.70	785	4.70	2,025	5.70	3,525
2.80	355	3.80	875	4.80	2,175	5.80	3,675
2.90	375	3.90	965	4.90	2,325	5.90	3,825
3.00	400	4.00	1,065	5.00	2,475	6.00	3,975
3.10	435	4.10	1,180	5.10	2,625	6.20	4,275
3.20	475	4.20	1,310	5.20	2,775	6.40	4,575
3.30	525	4.30	1,450	5.30	2,925	6.60	4,875
3.40	585	4.40	1,590	5.40	3,075	6.80	5,175
3.50	645	4.50	1,730	5.50	3,225	7.00	5,475

The preceding table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is fairly well defined between gage heights 3.1 feet and 6.4 feet. The table has been extended beyond these limits. Above gage height 5.0 feet the rating curve is a tangent, the difference being 150 per tenth.

Estimated monthly discharge of West Gallatin River at Salesville, Mont., for 1904.

[Drainage area, 860 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	435	335	369	22,689	0.429	0.495
February	435	335	351	20,190	.408	.440
March	355	320	336	20,660	.391	.451
April	1,310	335	612	36,416	.712	.794
May	5,775	1,065	2,563	157,593	2.980	3.436
June	5,700	3,000	4,400	261,818	5.116	5.708
July	3,525	965	2,053	126,234	2.387	2.752
August	920	455	653	40,151	.759	.875
September	555	455	506	30,109	.588	.656
October	525	435	482	29,637	.560	.646
November	435	400	421	25,051	.490	.547
December	400	335	372	22,873	.432	.498
The year	5,775	320	1,093	793,421	1.271	17.298

GALLATIN RIVER AT LOGAN, MONT.

This station was established August 24, 1893, by F. H. Newell, at the railroad pump house immediately below the Northern Pacific Railway bridge crossing Gallatin River at Logan, Mont. The gage was a vertical rod fastened to the cribwork box sunk in the river for the protection of the inlet pipe of the pump. The bench marks consisted of nails driven into the angle of the pier of the bridge facing the gage, these being placed at the elevation of the 7, 8, 9, and 10 foot marks, and designated by corresponding figures. At the bridge itself measurements of volume can not well be made, as the stream is divided into four channels, being very swift in two of these and obstructed by piles, snags, and sand in the others. Above the bridge, however, is a broad straight course, where measurements can be made by means of a boat and cable.

On March 10, 1894, the gage rod was washed out, together with the crib to which it was attached, no discharge measurements having been made while it was in place.

On November 16, 1894, a new gage was established by Arthur P. Davis, under the northeast corner of the Northern Pacific Railway bridge above mentioned. This gage consisted of timbers partly inclined and partly vertical, the lower inclined portion being graduated from 0.6 foot up to 7.1 feet and the vertical portion from 7 feet up to 12.1 feet. Bench mark No. 1 was on the head of a bridge spike in the top of the pile stump to which the lower end of the inclined gage was fastened. Its elevation was 1.62 feet above the zero of the gage. Bench mark No. 2 was the head of a bridge spike driven horizontally into the first pier east of the river. It was driven into the north end and was marked "B. M." Its elevation was 9.32 feet above the zero of the gage. The measurements were made by means of a cable across the river 100 yards above the bridge.

On September 16, 1896, a wire gage was placed in the east span of the railroad bridge and fastened to the guard rail on the upper side. The distance from the outside edge of the pulley to the end of the rod was 1 foot; from the end of the weight to the index marker was 18.4 feet. Bench mark No. 1 was the top of the northeast corner of the iron plate at the foot of the diagonal end member of the truss at the east end on the upper side, and was 13.7 feet above datum. Bench mark No. 2 was a spike in a pile stump, described and called "Bench mark No. 1" in the description of the 1894 gage.

The present station is located 450 feet northeast of the railroad bridge and 600 feet northwest of the railroad station. It was established in October, 1901, by J. S. Baker. The standard chain gage is placed on a horizontal frame 20 feet east of the south cable support. The chain length from end of weight to the outside of handle ring is 21.21 feet. The gage is read once each day by N. A. Smith. Discharge measurements are made by means of a cable, car, stay wire, and tagged wire about 450 feet above the railroad bridge. The initial point for soundings is the left cable support. The channel is straight for 200 feet above and below the station. The current has a moderate velocity. The right bank is high and rocky and is not liable to overflow. The left bank is low, but will overflow only at extremely high stages. Both banks are covered with bushes. The bed of the stream is sandy, with a small amount of vegetation. On July 27, 1901, the datum of the gage was raised 1.23 feet. The bench marks in present use are located as follows: Bench mark No. 1 is a railroad spike in the west side of the post of the gage frame, 3.6 feet from the top of the bridge bar. Its elevation is 8 feet above gage zero. Bench mark No. 2 is a temporary bench mark; it is a point halfway down on the bevel edge at the top of the coping of the northeast abutment of the Northern Pacific Railway bridge. Its elevation is 11.705 feet above gage zero.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Gallatin River at Logan, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 16	A. E. Place	150	556	2.51	2.34	1,399
April 24	do	150	563	2.61	2.45	1,467
May 24	W. B. Freeman	150	945	5.59	4.98	5,280
May 30	W. B. Freeman and E. C. Murphy.	151	782	4.26	4.08	3,330
June 18	W. B. Freeman	152	885	4.99	4.71	4,418
June 27	do	148	678	3.36	3.30	2,278
July 20	do	141	447	1.96	1.83	878
August 20	do	137	294	1.00	.78	294

Mean daily gage height, in feet, of Gallatin River at Logan, Mont., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.40	1.30	1.00	1.10	2.85	(b)	3.15	1.40	1.20	1.55	1.60	1.55
2	1.50	1.10	1.00	1.20	2.85	4.85	3.20	1.35	1.20	1.55	1.60	1.50
3	a1.80	1.00	1.00	1.30	2.90	4.80	3.30	1.20	1.20	1.60	1.60	1.50
4	a2.10	1.00	1.00	1.60	3.00	4.60	(b)	1.20	1.10	1.60	1.60	1.45
5	a2.80	1.10	1.00	1.90	3.00	4.50	3.20	1.15	1.10	1.60	1.60	1.45
6	a3.10	1.10	1.40	1.90	3.00	4.50	3.05	1.05	1.20	1.60	1.60	1.50
7	a3.60	1.10	1.50	1.70	3.10	4.60	2.80	1.05	1.20	1.60	1.60	1.50
8	a3.80	1.10	1.80	1.50	3.00	4.70	2.70	1.00	1.20	1.60	1.60	1.50
9	a2.90	1.30	1.40	1.60	2.80	4.60	2.60	1.00	1.20	1.60	1.60	1.50
10	1.50	1.40	1.20	1.90	2.90	(b)	2.50	.90	1.20	1.60	1.60	1.50
11	1.10	1.40	1.10	2.50	3.00	4.90	2.40	.85	1.20	1.60	1.60	1.60
12	1.00	1.50	1.10	2.50	3.00	4.95	2.30	.80	1.20	1.60	1.60	1.70
13	1.00	1.60	1.20	2.50	2.95	4.80	2.35	.75	1.20	1.60	1.60	1.80
14	1.00	1.60	1.20	2.30	2.95	4.60	2.35	.70	1.20	1.60	1.60	1.80
15	1.00	1.60	1.20	2.60	2.95	4.50	2.30	.60	1.20	1.60	1.60	1.85
16	1.00	1.50	1.20	2.30	3.15	4.50	2.15	.60	1.20	1.60	1.60	1.90
17	1.00	1.40	1.20	2.30	3.20	4.80	2.10	.60	1.20	1.60	1.60	1.85
18	1.00	1.40	1.20	2.00	3.40	4.75	2.10	.70	1.30	1.60	1.60	1.85
19	1.00	1.40	1.20	2.00	3.90	4.90	2.00	.70	1.40	1.60	1.60	1.85
20	1.00	1.40	1.20	2.10	(b)	4.65	1.80	.70	1.40	1.60	1.60	1.85
21	1.20	1.50	1.20	2.30	4.05	4.40	1.75	.60	1.40	1.60	1.60	1.85
22	1.30	1.30	1.20	2.30	4.60	4.30	1.70	.70	1.40	1.60	1.60	1.85
23	1.10	1.00	1.20	2.30	4.85	4.10	1.65	.80	1.40	1.60	1.60	1.85
24	1.15	.80	1.10	2.20	5.15	3.90	1.60	.85	1.40	1.60	1.60	1.85
25	1.20	1.00	1.00	2.20	5.00	3.80	1.60	.95	1.40	1.60	1.60	1.85
26	1.30	1.00	1.00	2.25	4.30	(b)	1.65	1.00	1.40	1.60	1.60	1.85
27	1.30	1.20	1.00	2.50	4.10	3.30	1.60	1.00	1.45	1.60	1.60	1.85
28	1.40	1.10	1.00	2.85	4.05	3.25	1.60	1.05	1.55	1.60	1.60	a4.10
29	1.20	1.00	1.20	3.00	4.10	3.25	1.60	1.10	1.55	1.60	1.60	a4.00
30	1.30	.....	1.20	2.85	4.30	3.20	1.60	1.00	1.60	1.60	1.60	a3.00
31	1.50	.....	1.20	.....	4.30	.....	1.50	1.10	.....	1.60	.....	a3.00

a Ice jam at railroad bridge (100 yards below station) from January 3 to 9 and December 28 to 31.
b No observation.

Rating table for Gallatin River at Logan, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	210	1.60	740	2.70	1,670	3.80	2,950
.60	230	1.70	810	2.80	1,770	3.90	3,090
.70	260	1.80	880	2.90	1,870	4.00	3,240
.80	300	1.90	955	3.00	1,980	4.20	3,540
.90	340	2.00	1,035	3.10	2,090	4.40	3,870
1.00	385	2.10	1,120	3.20	2,205	4.60	4,230
1.10	435	2.20	1,210	3.30	2,325	4.80	4,620
1.20	485	2.30	1,300	3.40	2,445	5.00	5,050
1.30	545	2.40	1,390	3.50	2,565		
1.40	605	2.50	1,480	3.60	2,685		
1.50	670	2.60	1,570	3.70	2,815		

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is well defined between gage heights 0.8 foot and 5 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Gallatin River at Logan, Mont., for 1904.

[Drainage area, 1,805 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January 11–31	670	385	[a]462	28,407	0.256	0.295
February	740	300	524	30,141	.293	.316
March	880	385	478	29,391	.265	.306
April	1,980	435	1,169	69,560	.648	.723
May	5,400	1,770	2,772	170,444	1.536	1.771
June	4,940	2,205	3,897	231,888	2.159	2.409
July	2,325	670	1,290	79,319	.715	.824
August	605	230	357	21,951	.198	.228
September	740	435	544	32,370	.301	.336
October	740	705	738	45,378	.409	.472
November	740	740	740	44,033	.410	.457
December [b]	955	635	825	50,727	.457	.527
The year	5,400	230	1,150	833,609	0.637	8.664

[a] Mean of January 11 to 31 is taken as mean for month.
[b] Discharge December 28 to 31 estimated 915 second-feet.

JEFFERSON RIVER NEAR SAPPINGTON, MONT.

This station was established November 13, 1894, by A. P. Davis. It is located 300 feet above the railroad bridge, 1 mile north of the

railroad station at Sappington, and 7 miles above Willow Creek. The chain gage is fastened to the guard rail on the upstream side of the south span of the old Northern Pacific Railway bridge. The length of the chain from the end of the weight to the marker is 16.30 feet. It is read twice each day by John Fraser. Discharge measurements were made by means of a cable, car, and tagged wire about 300 feet above the bridge to which the gage is attached. November 1 a new cable was installed some 500 feet above the old one on account of a new railroad bridge being built at the former site. The section at this place is an excellent one, the channel being straight for 500 feet above and below, the bed smooth and regular, covered with gravel, and entirely free from eddies. The current velocity is swift. Both banks are composed of clay and are covered with willows and underbrush. The right bank may overflow at extreme high water. On November 3, 1897, the gage datum was lowered 0.8 foot. The subsequent years were adjusted to the new datum, but the remainder of 1897 was corrected to agree with the old datum. Bench mark No. 1 consists of a 6-inch wire nail driven vertically in the east side of the blocking which forms the south abutment of the railroad bridge and is 12.90 feet above gage datum. Bench mark No. 2 is a 6-inch wire nail in a telegraph pole about 30 feet south and east of the south abutment of the bridge and is at an elevation of 9.93 feet above gage datum. Bench mark No. 3 is the head of the northwest bolt fastening the switch standard to the cross-tie 30 feet east of the bridge; its elevation is 17.70 feet above gage datum. Bench mark No. 4 is cross on top of coping at NW. corner of small culvert 800 feet from bridge. Elevation 11.568 feet above gage datum.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Jefferson River near Sappington, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 26	A. E. Place	270	1,248	4.10	4.40	5,126
May 18	W. B. Freeman	268	1,360	4.21	4.90	5,727
May 30	W. B. Freeman and E. C. Murphy.	268	1,457	4.77	5.43	6,949
June 28[a]	W. B. Freeman	250	1,041	3.39	3.65	3,533
July 23[a]	do	227	762	1.78	2.39	1,358
August 24[a]	W. B. Freeman and Robert Follansbee.	220	358	1.24	1.45	445
November 1[b]	L. R. Stockman	260	574	1.80	2.00	1,032

[a] From bridge below cable. [b] From a new section 300 feet above old cable section.

Mean daily gage height, in feet, of Jefferson River near Sappington, Mont., for 1904.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.05	4.10	4.10	2.40	5.00	5.45	3.15	2.05	1.65	1.55	2.00	2.50
2	4.10	4.10	4.10	2.40	4.80	5.50	3.10	1.95	1.65	1.55	2.00	2.45
3	4.10	4.10	4.10	2.40	4.75	5.80	3.05	1.95	1.65	1.55	2.00	2.30
4	4.25	4.10	4.15	2.40	5.15	5.85	3.05	1.95	1.65	1.55	2.05	2.30
5	4.30	4.10	4.20	2.40	5.50	5.60	3.15	1.85	1.65	1.55	2.10	2.30
6	4.30	4.10	4.30	2.40	5.35	5.45	3.40	1.80	1.65	1.65	2.10	2.20
7	4.30	4.10	4.55	2.40	4.90	5.45	3.60	1.70	1.65	1.65	2.20	2.20
8	4.30	3.85	4.30	2.40	4.85	5.30	3.30	1.60	1.60	1.65	2.20	2.20
9	4.20	3.80	3.45	2.40	4.75	5.25	3.25	1.45	1.55	1.65	2.20	2.20
10	4.30	3.80	2.70	2.40	4.50	5.15	3.15	1.60	1.55	1.65	2.20	2.20
11	4.35	3.70	2.50	2.50	4.45	5.10	3.15	1.65	1.55	1.65	2.20	2.20
12	4.40	3.75	2.40	2.65	4.55	4.95	3.15	1.60	1.55	1.65	2.20	2.10
13	4.40	3.80	2.40	2.90	4.55	4.70	3.15	1.50	1.55	1.80	2.20	2.15
14	4.50	3.80	2.40	3.00	4.55	4.50	3.15	1.55	1.55	1.75	2.20	2.30
15	4.50	3.80	2.40	3.25	4.60	4.35	3.15	1.55	1.55	1.85	2.20	2.30
16	4.50	4.05	2.40	3.35	4.90	4.35	3.05	1.55	1.55	1.90	2.20	2.25
17	4.50	4.20	2.40	3.30	4.95	4.35	2.85	1.55	1.55	1.95	2.20	2.20
18	4.50	4.20	2.40	3.30	4.90	4.35	2.60	1.55	1.55	1.95	2.20	2.30
19	4.40	4.20	2.30	3.30	5.00	4.35	2.50	1.55	1.55	1.95	2.35	2.30
20	4.15	4.20	2.30	3.55	5.15	4.45	2.45	1.55	1.55	1.95	2.50	2.20
21	3.75	4.20	2.30	4.10	5.30	4.40	2.45	1.55	1.55	2.05	2.50	2.20
22	3.90	4.20	2.30	4.20	5.50	4.20	2.45	1.50	1.55	2.15	2.45	2.20
23	3.90	4.20	2.30	4.35	5.65	4.10	2.35	1.45	1.55	2.15	2.40	2.20
24	3.90	4.20	2.40	4.40	6.35	4.15	2.35	1.45	1.55	2.05	2.45	2.20
25	3.90	4.10	2.35	4.50	6.45	4.15	2.35	1.45	1.55	2.05	2.50	2.20
26	3.90	4.15	2.25	4.55	6.65	4.00	2.25	1.45	1.55	2.05	2.50	2.60
27	3.95	4.20	2.20	5.00	6.45	3.90	2.25	1.45	1.55	2.05	2.50	3.30
28	4.00	4.20	2.35	5.50	5.85	3.70	2.20	1.45	1.55	2.05	2.50	3.50
29	4.00	4.10	2.40	5.55	5.55	3.40	2.15	1.50	1.55	2.00	2.50	6.40
30	4.05	.....	2.50	5.45	5.45	3.25	2.10	1.55	1.55	1.95	2.50	6.90
31	4.10	.....	2.50	.....	5.35	.....	2.05	1.60	.....	1.95	.....	7.00

[a] Readings from January 1 to March 9, 1904, inclusive, and from December 27–31, 1904, inclusive, do not represent the flow due to ice gorging.

Rating table for Jefferson River near Sappington, Mont., from March 10 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.50	505	2.60	1,720	3.70	3,635	4.80	5,725
1.60	585	2.70	1,860	3.80	3,825	4.90	5,915
1.70	680	2.80	2,000	3.90	4,015	5.00	6,105
1.80	780	2.90	2,150	4.00	4,205	5.20	6,485
1.90	880	3.00	2,315	4.10	4,395	5.40	6,865
2.00	990	3.10	2,495	4.20	4,585	5.60	7,245
2.10	1,100	3.20	2,685	4.30	4,775	5.80	7,625
2.20	1,210	3.30	2,875	4.40	4,965	6.00	8,005
2.30	1,325	3.40	3,065	4.50	5,155	6.20	8,385
2.40	1,450	3.50	3,255	4.60	5,345	6.40	8,765
2.50	1,580	3.60	3,445	4.70	5,535	6.60	9,145

The preceding table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is fairly well defined between gage heights 1.45 feet and 5.50 feet. The table has been extended beyond these limits. Above gage height 3.50 feet the rating curve is a tangent, the difference being 190 per tenth. Change in conditions due to obstructions placed in the river just below gage.

Estimated monthly discharge of Jefferson River near Sappington, Mont., for 1904.

[Drainage area, 8,984 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January			[a] 1,400	86,083	0.156	0.180
February			[a] 1,400	80,529	.156	.168
March [b]	1,860	1,210	1,433	88,112	.159	.183
April	7,150	1,450	3,218	191,484	.358	.399
May	9,240	5,060	6,516	400,653	.725	.836
June	7,720	2,780	5,440	323,702	.606	.676
July	3,445	1,045	2,055	126,357	.229	.264
August	1,045	465	606	37,262	.067	.077
September	630	545	566	33,679	.063	.070
October	1,155	545	·824	50,666	.092	.106
November	1,580	990	1,308	77,831	.146	.163
December [c]	1,720	1,100	1,353	83,193	.151	.174
The year			2,177	1,579,551	.242	3.296

[a] Estimated by C. C. Babb.
[b] March 10 to 31, inclusive. Mean for 22 days taken as mean for month.
[c] Discharge December 27 to 31 estimated 1,720 second feet.

SUN RIVER (NORTH FORK) NEAR AUGUSTA, MONT.

This station was established October 31, 1903, by C. T. Prall. It is located below Christian's ranch and below the head of Kilraven ditch, 14 miles northwest of Augusta and 21 miles southwest of Choteau, in Lewis and Clark County, Mont. The chain gage is on the left bank about 250 feet below the cable. The horizontal scale board is painted white, and is nailed to a plank, which is bolted to three posts set in the ground. The length of the chain from the end of the weight to the marker is 13.05 feet. The distance from the outside edge of the pulley to the zero of the scale is 4 feet. Bench mark No. 1 is the highest point of rock in Sun River, 12 feet upstream from gage. The size of the rock is 4 cubic yards. The elevation of the bench mark is 3.94 feet above the zero of the gage. Bench mark No. 2 is a nail in the root of a cottonwood tree 15 feet east of the gage. Its elevation is 14.47 feet above the zero of the gage. Bench mark No. 3 is a nail in

the post which supports the inshore end of the gage. Its elevation is 10.69 feet above the zero of the gage. Discharge measurements are made by means of a cable, car, tag wire, and stay wire. The channel is straight for about 300 feet above and 200 feet below the station. The right bank is low and may overflow at flood stages; the left bank is high and rocky. The bed of the stream is of solid rock. The current is sluggish. The initial point for soundings is the left cable strut. Owing to the impossibility of obtaining a regular observer but few gage readings were made during the year.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Sun River (North Fork) near Augusta, Mont., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
November 1	C. T. Prall	378	1.19	1.00	453
1904.					
July 8	A. P. Porter	518	2.73	2.42	1,416
July 9	do	522	2.86	2.45	1,492
July 19	do	404	1.88	1.70	760
September 8	do	291	.92	.81	269
November 12	L. R. Stockman	260	.60	.60	158

Mean daily gage height in feet of Sun River (North Fork) near Augusta, Mont., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
8	2.40		0.80			
9	2.45					
10	2.35					
11	2.30					
12					0.60	
15	1.95					
16	1.90					
17	1.80					
18	1.80					
19	1.70					
20	1.70					
21	1.65					
23	1.60					
25	1.55					
30					.60	

SUN RIVER (SOUTH FORK) NEAR AUGUSTA, MONT.

This station was established by Arthur P. Porter, December 2, 1904. It is located at the highway bridge on the road from Augusta to Craig, Mont., about one-half mile out of Augusta. The gage is a vertical rod, spiked to the cribwork of the east abutment on its downstream side. It is graduated to feet and tenths. The gage reader is Richard Auchard, and readings are made daily. The measurements are made from the upstream side of the single-span bridge. The initial point for sounding is at the east end of the hand rail, and this point, as well as the distances every 5 feet apart, is marked in white paint. The channel above the station is straight for a few feet and then curves to the right. Below it is straight for 30 feet, when it forks into two parts. The current is sluggish. Both banks are high and not liable to overflow. At the station the water passes between the cribworks of the bridge abutments. The river bed is made up of coarse gravel and cobblestones. Two sloughs on the east side and an irrigation ditch on the west side of the bridge carry water past the point of measurement. Bench mark is the head of a spike surrounded by a ring of nails in the top of the east abutment on the downstream side. It is 4.89 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurement of Sun River (South Fork) near Augusta, Mont., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
December 2	A. P. Porter	51.4	0.45	1.30	23.3

Mean daily gage height in feet of Sun River (South Fork) near Augusta, Mont., for 1904.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
2	1.30	10	1.20	18	1.30	26	(a)
3	1.30	11	1.30	19	1.20	27	1.50
4	1.30	12	1.30	20	1.20	28	1.45
5	1.30	13	1.30	21	1.20	29	1.50
6	1.50	14	1.15	22	1.20	30	1.30
7	1.55	15	1.10	23	1.00	31	1.20
8	1.25	16	1.20	24	1.30		
9	1.20	17	1.30	25	(a)		

(a) Ice.

MARIAS RIVER NEAR SHELBY, MONT.

This station was established April 4, 1902, by J. S. Baker. It is located at the highway bridge near J. A. Johnston's ranch, 7 miles south of Shelby, Mont., from which point it is reached by driving. The gage is of the standard chain type, and the scale board is spiked to the upstream hand rail of the bridge. The length of the chain from the weight to the marker was originally 22.06 feet, but had to be reduced November 16, 1904, to 21.97 feet, on account of settling of the bridge. It is read once each day by Elsie Bailey. Discharge measurements are made from the highway bridge, the lower chord of which is about 15 feet above low water. The initial point for soundings is the east end of the east bridge pier, on the lower side of the bridge, on the left bank. It is marked 0. The channel is straight for 300 feet above and 600 feet below the station. The current velocity is moderate. The right bank is sloping and sandy, and is liable to overflow. The left bank is high, and is protected by sheet piling and a plank wall. It may overflow at extreme flood stages. The bed of the stream is composed of sand and gravel, with some cobblestones; it is liable to shift after freshets. There is but one channel, and the current flows toward the left bank. Bench mark No. 1 is a rivet head in the footplate at the foot of the batter post on the top of the southeast pier. The plate is marked "B. M. 17.54" with black paint. The elevation of the bench mark above gage datum is 17.54 feet. Bench mark No. 2 is a spike in the southwest side of a cottonwood stump 25 feet southeast of the southeast pier. It is marked "B. M. 11.24." Its elevation above gage datum is 11.24 feet. Observations had to be discontinued November 19, 1904, on account of the only available observer leaving.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Marias River near Shelby, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 8	A. E. Place	170	546	4.31	4.02	2,359
May 20	L. R. Stockman	70	603	4.86	4.34	2,934
May 27	do	75	611	4.92	4.44	3,004
June 10	W. B. Freeman	178	604	4.63	4.31	2,798
June 29	Robert Follansbee	162	444	2.93	3.35	1,303
August 1	W. B. Freeman	143	271	1.83	2.44	495
September 5	do	135	204	1.13	1.97	231
November 16	L. R. Stockman	124	199	.93	1.80	184

Mean daily gage height, in feet, of Marias River near Shelby, Mont., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.00	.....	.....	.....	4.30	4.70	3.45	2.45	2.15	1.80	1.80
2	3.10	.....	.....	.....	4.30	4.80	3.35	2.45	2.15	1.80	1.80
3	3.10	.....	.....	.....	4.30	4.60	3.45	2.35	2.05	1.80	1.80
4	3.20	.....	.....	.....	4.40	4.40	3.55	2.35	2.05	1.80	1.80
5	3.20	.....	.....	.....	4.20	4.30	3.45	2.35	2.05	1.80	1.80
6	3.30	.....	.....	.....	4.10	4.40	3.35	2.35	1.95	1.80	1.80
7	3.30	.....	.....	.....	3.90	4.60	3.75	2.35	1.95	1.90	1.80
8	3.30	.....	.....	7.20	3.80	4.60	3.25	2.35	1.95	1.90	1.80
9	3.30	.....	.....	6.30	3.80	4.50	3.25	2.35	1.95	1.90	1.80
10	3.40	.....	.....	5.40	3.80	4.30	3.15	2.35	1.95	2.00	1.80
11	3.30	.....	.....	5.00	3.90	4.30	3.15	2.25	1.95	2.00	1.80
12	3.30	.....	.....	4.30	4.00	4.20	3.05	2.25	1.95	1.90	1.80
13	3.20	.....	.....	4.40	3.90	4.00	3.05	2.25	1.95	1.90	1.80
14	3.10	.....	.....	4.20	3.90	3.90	3.05	2.25	1.95	1.90	1.80
15	3.10	.....	.....	4.10	4.00	4.00	2.95	2.15	1.95	1.90	1.80
16	3.10	.....	.....	3.90	4.10	4.00	2.95	2.15	1.95	1.90	1.70
17	3.10	.....	.....	3.80	4.10	4.20	2.85	2.15	1.95	1.90	1.70
18	[a]3.00	.....	.....	3.50	4.20	4.40	2.75	2.15	1.95	1.90	1.70
19	.....	.....	.....	3.50	4.35	4.40	2.75	2.15	1.95	1.90	1.70
20	.....	.....	.....	3.80	4.40	4.20	2.65	2.15	1.95	1.90	[b]
21	.....	.....	.....	3.90	4.50	4.00	2.65	2.05	1.95	1.80	.....
22	.....	.....	.....	4.00	4.70	3.80	2.55	2.05	1.95	1.80	.....
23	.....	.....	.....	4.00	5.40	3.80	2.45	2.15	1.95	1.80	.....
24	.....	.....	.....	3.80	5.10	3.80	2.45	2.15	1.95	1.80	.....
25	.....	.....	.....	3.80	4.90	3.60	2.45	2.05	1.95	1.80	.....
26	.....	.....	.....	3.80	4.60	3.60	2.35	2.05	1.85	1.80	.....
27	.....	.....	.....	3.80	4.50	3.50	2.45	2.05	1.85	1.80	.....
28	.....	.....	.....	4.00	4.30	3.30	2.45	2.05	1.85	1.80	.....
29	.....	.....	.....	4.60	4.50	3.40	2.45	2.05	1.85	1.80	.....
30	.....	.....	.....	4.60	4.60	3.40	2.45	2.15	1.85	1.80	.....
31	.....	.....	.....	.....	4.70	.....	2.45	2.15	.....	1.80	.....

[a] River frozen January 18 to April 7, inclusive.
[b] Readings discontinued for lack of an observer.

Rating table for Marias River near Shelby, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.70	150	2.80	725	3.90	2,140	5.00	4,160
1.80	185	2.90	810	4.00	2,300	5.20	4,560
1.90	220	3.00	900	4.10	2,460	5.40	4,960
2.00	265	3.10	995	4.20	2,620	5.60	5,360
2.10	310	3.20	1,110	4.30	2,790	5.80	5,760
2.20	360	3.30	1,240	4.40	2,970	6.00	6,160
2.30	410	3.40	1,380	4.50	3,160	6.20	6,560
2.40	460	3.50	1,530	4.60	3,360	6.40	6,960
2.50	515	3.60	1,680	4.70	3,560	6.60	7,360
2.60	575	3.70	1,830	4.80	3,760	6.80	7,760
2.70	645	3.80	1,980	4.90	3,960		

The preceding table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 1.8 feet and 4.5 feet. The table has been extended beyond these limits. Above gage height 4.5 feet the rating curve is a tangent, the difference being 200 per tenth.

Estimated monthly discharge of Marias River near Shelby, Mont., for 1904.

[Drainage area, 2,610 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January 1 to 18, inclusive	1,380	900	[a]900	55,339	0.345	0.398
February			[a]800	46,016	.307	.331
March			[a]800	49,190	.307	.354
April 1 to 7, estimated	8,560	800	2,457	146,202	.941	1.050
May	4,960	1,980	2,848	175,117	1.091	1.258
June	3,760	1,240	2,495	148,463	.956	1.067
July	1,605	435	871	53,556	.334	.385
August	490	290	367	22,566	.141	.162
September	335	205	246	14,638	.094	.105
October	265	185	204	12,544	.078	.090
November [b]	185	150	168	9,997	.064	.071
December			[a]150	9,223	.057	.066
The year			1,017	742,851	.393	5.337

[a] Estimated. [b] Discharge estimated for November 20 to 30.

TETON RIVER NEAR BELLEVIEW, MONT.

This station was established November 26, 1904, by A. P. Porter. It is located in sec. 35, T. 25 N., R. 37 W., M. P. M., about 16 miles above Choteau, and near the house of Julius Bjornstad. The nearest post-office is Belleview, Mont. The gage is a vertical rod gage graduated to feet and tenths. It is spiked to a 2 by 4 inch post and set in a pit about 2 feet in diameter and about 40 feet above the head of an irrigation ditch. It is read daily by Julius Bjornstad. Stream measurements are made from a cable a short distance upstream. This is supported on one side by shears and a deadman; on the other, by trees. The tagged wire stretched over the cable is marked every 10 feet. The zero is at the left and serves as an initial point for soundings. The channel above the station is straight for about 200 feet at low water. At high water the river curves gradually from the left. Below the channel is straight for 75 feet. The bed is free from vegetation and consists of coarse gravel and cobblestones. A bar divides

the channel at low water. Some 100 feet downstream there are small rapids. The current is swift. Both banks are low and covered with thick underbrush and a few scattering trees. Bench mark No. 1 is a nail in a 10-inch cottonwood tree 8 feet from the road and 50 feet from the river bank. Its elevation is 5.43 above gage zero. Bench mark No. 2 is a nail in a 5-inch cottonwood tree 2 feet to the east of the road and 50 feet from the bank. Its elevation is 5 feet above gage zero. Bench mark No. 3 is a nail in a 20-inch cottonwood tree serving as a post in Bjornstad's small corral. Its elevation above the gage zero is 3.165 feet.

Observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurement of Teton River near Belleview, Mont., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
November 27	A. P. Porter	38.2	1.52	0.60	58.0

Mean daily gage height, in feet, of Teton River near Belleview, Mont., for 1904.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1		0.60	12		0.55	22		0.60
2		.60	13		.50	23		.60
3		.60	14		.50	24		.60
4		.55	15		.50	25		.70
5		.55	16		.50	26		
6		.50	17		.50	27	0.60	
7		.55	18		.50	28	.60	
8		.55	19		.60	29	.60	.55
9		.55	20		.60	30	.60	.40
10		.55	21		.60	31		.40
11		.55						

TETON RIVER NEAR CHOTEAU, MONT.

This station was established November 30, 1904, by A. P. Porter. It is located at the highway bridge on the road from Choteau to Augusta, Mont., and is about 1½ miles from the town of Choteau. The equipment consists of a chain gage fastened to the upstream hand rail of the bridge, and a graduated scale board. The distance from the tip of the weight to the marker is 14.73 feet. The marker is a a copper wire index. The gage is read gratuitously by J. W. Shields. The bridge, from the upstream side of which measurements are made, is a wooden structure resting on pile bents. The initial point for sounding is at the northeast end of the bridge, and is marked "0" in

white paint. The upstream hand rail is divided into 10-foot stations, and their distances from zero are painted. Above the station the channel is straight for 200 feet, below it curves to the right for about 50 feet. The current is swift. The river bed is clean from vegetation, and covered with rocks and coarse gravel. The bank is high on the right and low on the left, and is subject to overflow at high water. Bench mark No. 1 is a nail in a 3-inch plank just back of the floor beam at the west end of the bridge. It is marked with white paint and has an assumed elevation of 20.00 feet. Bench mark No. 2 is a nail 2 feet above ground in the trunk of a cottonwood tree 100 feet from the east end of the bridge, and in the fence on the south side of the road. Its elevation is 17.79 feet. The zero of the gage is 10.92 feet with reference to the bench marks. This gage was stolen before any observations could be made, and it was not replaced before the close of the year.

Discharge measurement of Teton River near Chotean, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
November 29 ..	A. P. Porter	15	5.8	1.25	1.8	7.3

MILK RIVER AT HAVRE, MONT.

This station was originally established by Cyrus C. Babb May 15, 1898. At that time a cable was stretched across the river not far from the highway bridge. The station was reestablished November 4, 1902, by L. V. Branch, when the cable was taken out and the station was transferred to the highway bridge, at which it is now located. The original wire gage was replaced January 12, 1904, by a standard chain gage, which was made to read the same as the old gage. The length of chain from the end of the weight to the marker is 25.3 feet. The marker is a ring of fine copper wire wrapped around the chain. It is placed 0.85 foot from the end of the cast-iron ring at the end of the chain. The scale is nailed to the floor of the bridge on the downstream side 90 to 100 feet from the initial point for soundings. It is boxed, and reads from 2.5 to 10.5 feet. The gage pulley is located at a point which corresponds to a reading of 2 feet on the scale. L. H. Ling, who reads the gage, is the United States Weather Bureau observer. Discharge measurements are made from the downstream side of the bridge to which the gage is attached. The initial point for soundings is marked on the downstream guard rail at the right bank. The channel is straight above for a short distance, when a sharp curve occurs. Below the station it is straight. The current is sluggish at ordinary stages. Both banks are high above all ordinary floods, and

are not wooded. The bed of the stream is shifting and is liable to change after each freshet. The bridge from which the measurements are made makes an angle of 20 degrees with the normal to the current. The datum used in the establishment of the bench marks is that of the city of Havre, deduced from a destroyed temporary bench mark of the United States Geological Survey. Bench mark No. 2 is a 20-penny nail in a cottonwood tree 100 feet southwest of the southwest pier of the bridge. Its elevation is 2,477.44 feet. Bench mark No. 3 is a standard United States Geological Survey bench-mark plate in the stone pier of a column supporting the Great Northern Railway water tank one-half mile southeast of the bridge and near the round-house. It is marked 2,483. The correct elevation is 2,482.46 feet. There is also a temporary bench mark on the top of the southeast corner of the lid of the gage box. Its elevation is 2,488.60 feet.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Milk River at Havre, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 12	A. E. Place	172	744	3.86	7.78	2,866
May 5	do	168	289	2.03	5.18	588
May 19	L. R. Stockman	75	124	2.90	4.37	359
May 26	do	90	159	1.69	4.43	289
June 4	E. C. Murphy and W. B. Freeman.	155	252	1.73	4.93	435
June 30	Robert Follansbee	62	70	1.34	3.47	95
July 18	do	56	37	1.19	3.02	44
August 1	W. B. Freeman	24	11	1.10	2.80	12
August 10	do	7	5	.69	2.45	3

Mean daily gage height, in feet, of Milk River at Havre, Mont., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	.....	4.60	4.80	4.80	3.40	2.80	2.40	2.50	2.80
2	.....	.....	.....	4.70	4.80	5.00	3.40	2.65	2.50	2.60	2.85
3	.....	.....	.....	7.00	5.00	5.00	3.40	2.60	2.60	2.50	2.80
4	.....	.....	.....	8.00	5.00	4.90	3.40	2.50	2.60	2.50	2.80
5	.....	.....	.....	8.80	5.20	4.70	3.40	2.50	2.60	2.40	2.90
6	.....	.....	.....	8.00	5.20	4.60	3.30	2.40	2.50	2.40	2.90
7	.....	.....	.....	9.30	5.00	4.60	3.30	2.40	2.50	2.50	2.90
8	.....	.....	.....	8.20	4.90	4.70	3.30	2.45	2.50	3.00	2.90
9	.....	.....	.....	7.80	4.90	4.80	3.30	2.40	2.40	2.90	2.90
10	.....	.....	.....	7.30	4.90	4.80	3.10	2.40	2.40	2.80	2.90
11	.....	.....	.....	6.80	4.80	4.90	3.00	2.40	2.40	2.70	2.90

[a] River frozen January 1 to March 30, inclusive; also during December.

Mean daily gage height, in feet, of Milk River at Havre, Mont., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
12	.....	.....	.....	8.00	4.80	4.60	3.00	2.30	2.30	2.70	2.90
13	.....	.....	.....	9.30	4.60	4.60	3.00	2.25	2.40	2.70	2.90
14	.....	.....	.....	8.00	4.45	4.50	3.00	2.25	2.40	2.60	2.90
15	.....	.....	.....	7.00	4.40	4.40	3.00	2.20	2.40	2.80	2.90
16	.....	.....	.....	6.70	4.50	4.40	3.00	2.10	2.40	2.80	2.90
17	.....	.....	.....	6.20	4.50	4.10	3.00	2.10	2.35	2.80	2.90
18	.....	.....	.....	5.90	4.50	4.15	3.00	2.10	2.30	2.80	3.10
19	.....	.....	.....	5.60	4.40	4.10	2.90	2.10	2.30	2.90	3.10
20	.....	.....	.....	5.30	4.30	4.10	2.90	2.10	2.30	2.90	3.00
21	.....	.....	.....	5.10	4.20	4.00	2.90	2.20	2.30	2.90	3.00
22	.....	.....	.....	5.00	4.20	4.00	2.85	2.50	2.20	2.90	3.00
23	.....	.....	.....	5.10	4.30	3.80	2.85	2.40	2.20	2.80	3.00
24	.....	.....	.....	5.30	4.60	3.70	2.80	2.50	2.20	2.80	3.00
25	.....	.....	.....	5.30	4.80	3.60	2.70	2.50	2.20	2.80	3.00
26	.....	.....	.....	5.00	4.55	3.70	2.70	2.60	2.20	2.80	3.00
27	.....	.....	.....	5.20	4.50	3.60	2.60	2.60	2.20	2.80	3.00
28	.....	.....	.....	5.10	4.55	3.60	2.60	2.50	2.20	2.80	3.00
29	.....	.....	.....	4.90	4.70	3.60	2.60	2.40	2.20	2.80	3.00
30	.....	.....	.....	4.80	4.70	3.50	2.60	2.40	2.40	2.80	3.00
31	.....	.....	4.50	.....	4.70	.....	2.60	2.40	.....	2.80	.....

Rating table for Milk River at Havre, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	1	3.60	120	5.00	490	6.80	1,750
2.30	2	3.70	135	5.10	535	7.00	1,950
2.40	3	3.80	150	5.20	580	7.20	2,165
2.50	5	3.90	170	5.30	630	7.40	2,390
2.60	10	4.00	190	5.40	685	7.60	2,630
2.70	15	4.10	210	5.50	745	7.80	2,880
2.80	22	4.20	230	5.60	805	8.00	3,140
2.90	31	4.30	255	5.70	870	8.20	3,400
3.00	41	4.40	280	5.80	935	8.40	3,665
3.10	51	4.50	310	5.90	1,005	8.60	3,935
3.20	63	4.60	340	6.00	1,075	8.80	4,205
3.30	75	4.70	375	6.20	1,225	9.00	4,480
3.40	90	4.80	410	6.40	1,390	9.20	4,760
3.50	105	4.90	450	6.60	1,565		

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is fairly well defined between gage heights 2.45 feet and 7.80 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Milk River at Harre, Mont., for 1904.

[Drainage area, 7,300 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a] 90	5,534	0.012	0.014
February	.....	.....	[a] 75	4,314	.010	.011
March	.....	.....	[a] 75	4,612	.010	.012
April	4,900	340	1,736	103,299	.238	.266
May	580	230	373	22,935	.051	.059
June	490	105	278	16,542	.038	.042
July	90	10	44	2,705	.006	.007
August	22	0	5	307	.000	.000
September	10	1	3	178	.000	.000
October	41	3	19	1,168	.003	.003
November	51	22	35	2,083	.005	.006
December	.....	.....	[a] 25	1,537	.003	.003
The year	.....	.....	230	165,214	.031	.423

[a] Estimated by C. C. Babb.

MILK RIVER AT MALTA, MONT.

This station was established July 31, 1902, by C. T. Prall. It is located at the highway bridge on the main road one-fourth mile east of the railroad station and post-office at Malta, Mont. The original wire gage has been replaced by a standard boxed chain gage, reading the same as the old one. It is fastened to the lower downstream guard rail of the highway bridge. The length of the chain from the end of the weight to the marker is 28.67 feet. The distance from the zero of the scale to the outside edge of the pulley is 0.5 foot. The marker is a small copper ring near the ring at the end of the chain. The gage is read once each day by S. C. Loyd. Discharge measurements are made from the downstream side of the bridge to which the gage is attached. The initial point for soundings is a spike on the downstream guard rail at the right bank. It is marked zero with paint. The channel is straight for about 700 feet above and 250 feet below the station. The current velocity is moderate. Both banks are high and sandy and are not liable to overflow. The water passes beneath the bridge at all stages. The bed of the stream is composed of sand and gravel, and there is but one channel. The bench mark is a paint mark on the east end of a plank spiked to the south abutment. It is marked "B. M. U. S. G. S." Its elevation above gage datum is 13.66 feet, and the elevation of the latter above sea level is 2,221.40,

or 37.80 feet below the United States Geological Survey datum at the Malta schoolhouse.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Milk River at Malta, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 8[a]	W. B. Freeman	150	1,261	2.51	10.45	3,162
April 10	do	153	1,962	4.14	14.35	8,116
April 11	do	153	1,682	4.16	12.57	7,002
April 12	do	145	1,530	4.55	11.94	6,966
April 13	do	145	1,536	4.44	12.07	6,830
April 13	do	145	1,505	4.35	11.83	6,545
April 15	do	145	1,467	4.49	11.82	6,583
April 18	do	143	1,077	4.45	9.47	4,798
April 18	do	143	990	4.52	8.85	4,475
April 19	do	142	830	4.64	7.80	3,853
April 19	do	141	736	4.73	7.12	3,483
April 20	do	135	575	4.86	6.06	2,792
April 20	do	131	485	5.10	5.52	2,470
April 21	do	116	386	4.85	4.84	1,871
April 22	do	106	333	4.70	4.43	1,566
April 23	do	106	327	4.38	4.19	1,432
April 24	do	103	321	4.40	4.07	1,408
April 24	do	103	321	4.33	4.07	1,390
April 26	do	100	313	4.41	4.06	1,381
April 30	do	94	262	4.03	3.62	1,056
May 5	do	95	236	4.00	3.29	942
May 5	W. M. Neptune	98	238	3.57	3.29	850
May 17	Robert Follansbee	86	160	2.66	2.42	425
May 25	do	83	130	2.52	2.20	327
June 4	W. B. Freeman and E. C. Murphy.	87	146	3.45	2.37	503
June 6	Robert Follansbee	138	476	4.59	5.35	2,182
June 7	do	135	468	4.97	5.08	2,324
June 9	do	110	318	4.34	3.98	1,382
June 13	do	93	196	3.07	2.90	601
June 15	do	92	188	3.12	2.86	588
July 5[b]	do	22	21	2.09	1.34	44
July 9[b]	do	20	19	1.00	1.06	19
July 20[b]	do	18	14	.41	.90	6.6
July 28	do				.71	[c]1

[a] Ice gorge. [b] By wading at different sections. [c] Estimated.

Mean daily gage height, in feet, of Milk River at Malta, Mont., for 1904.

Date.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.[a]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.55	.....	.....	.....	3.65	2.00	1.30	0.70	0.30	0.30	0.30	1.00
2	1.55	.....	.....	.....	3.65	2.10	1.30	.70	.30	.30	.30	1.00
3	1.75	.....	.....	1.75	3.55	2.00	1.30	.70	.30	.30	.30	1.00
4	2.65	.....	.....	2.85	3.55	2.00	1.30	.70	.30	.30	.30	1.00
5	2.55	1.65	1.65	[b]5.85	3.35	4.60	1.30	.70	.30	.30	.30	1.00
6	2.45	.....	.....	8.35	3.25	5.30	1.30	.70	.30	.30	.30	1.00
7	2.45	.....	.....	9.35	3.15	4.40	1.20	.70	.30	.30	.30	1.00
8	2.35	.....	.....	10.55	3.05	4.00	1.10	.70	.30	.30	.30	1.00
9	2.15	.....	.....	[c]15.15	3.05	3.50	1.05	.70	.30	.30	.30	1.00
10	1.95	1.65	1.65	15.15	2.95	3.30	1.05	.65	.30	.30	[d].50	1.00
11	1.65	.....	.....	12.55	2.95	2.90	1.05	.65	.30	.30	1.30	1.00
12	1.55	.....	.....	11.95	2.85	2.90	1.00	.65	.30	.30	1.30	1.00
13	1.55	.....	.....	12.05	2.75	2.90	1.00	[d].60	.30	.30	1.30	1.00
14	1.45	.....	.....	11.45	2.65	2.80	1.00	.55	.30	.30	1.20	1.00
15	1.35	1.65	1.65	11.45	2.55	2.80	1.00	.55	.30	.30	1.10	1.00
16	1.35	.....	.....	11.45	2.45	2.70	1.00	.55	.30	.30	1.00	1.00
17	1.35	.....	.....	11.65	2.35	2.40	.90	.50	.30	.30	1.00	1.00
18	1.65	.....	.....	9.45	2.25	2.30	.90	.45	.30	.30	1.00	1.00
19	1.65	.....	.....	7.95	2.25	2.20	.90	.40	.30	.30	1.00	1.00
20	2.45	1.65	1.65	6.05	2.25	2.10	.90	.40	.30	.30	1.00	1.00
21	1.75	.....	.....	4.85	2.35	2.10	.90	.40	.30	.30	1.00	1.00
22	1.75	.....	.....	4.45	2.20	2.00	.85	.40	.30	.30	1.00	1.00
23	[e]1.65	.....	.....	4.25	2.50	1.90	.80	.40	.30	.30	1.00	1.00
24	1.65	.....	.....	4.05	2.30	1.80	.80	.40	.30	.30	1.00	1.00
25	1.65	1.65	1.65	4.05	2.20	1.70	.80	.40	.30	.30	1.00	1.00
26	1.65	.....	.....	4.05	2.10	1.60	.80	.40	.30	.30	1.00	1.00
27	1.65	.....	.....	4.05	1.90	1.60	.80	.40	.30	.30	1.00	1.00
28	1.65	.....	.....	4.05	1.90	1.50	.70	.40	.30	.30	1.00	1.00
29	1.65	.....	.....	3.75	2.00	1.40	.70	.40	.30	.30	1.00	1.00
30	1.65	.....	.....	3.55	2.10	1.30	.70	.40	.30	.30	1.00	1.00
31	1.65	.....	.....	.....	2.10	.....	.70	.40	.....	.30	.....	1.10

[a] River frozen January 1 to April 3, when ice goes out at station.
[b] April 5 to 10, water backed up by ice jam.
[c] Maximum gage height, 16 feet (approximate).
[d] No flow August 13 to November 10. Water standing in pools.
[e] January 23 to April 3, gage height is 1.65 read to ice.

Rating table for Milk River at Malta, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.70	1	2.50	472	4.60	1,735	8.20	4,075
.80	4	2.60	520	4.80	1,865	8.40	4,205
.90	8	2.70	568	5.00	1,995	8.60	4,335
1.00	15	2.80	618	5.20	2,125	8.80	4,465
1.10	24	2.90	670	5.40	2,255	9.00	4,595
1.20	34	3.00	722	5.60	2,385	9.50	4,945
1.30	45	3.10	778	5.80	2,515	10.00	5,295
1.40	58	3.20	834	6.00	2,645	10.50	5,645
1.50	76	3.30	894	6.20	2,775	11.00	5,995
1.60	102	3.40	958	6.40	2,905	11.50	6,345
1.70	136	3.50	1,022	6.60	3,035	12.00	6,695
1.80	174	3.60	1,086	6.80	3,165	12.50	7,045
1.90	214	3.70	1,150	7.00	3,295	13.00	7,395
2.00	254	3.80	1,215	7.20	3,425	13.50	7,745
2.10	294	3.90	1,280	7.40	3,555	14.00	8,095
2.20	336	4.00	1,345	7.60	3,685	14.50	8,445
2.30	380	4.20	1,475	7.80	3,815	15.00	8,795
2.40	424	4.40	1,605	8.00	3,945		

The above table is applicable only for open-channel conditions. It is based upon 34 discharge measurements made during 1904. It is well defined between point of zero flow and 14 feet gage height. Above gage height 9 feet the rating curve is a tangent, the difference being 70 per tenth.

Estimated monthly discharge of Milk River at Malta, Mont., for 1904.

[Drainage area, 14,044 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	----------	----------	[a] 100	6,149	0.007	0.008
February	----------	----------	[a] 80	4,602	.006	.006
March	----------	----------	[a] 80	4,919	.006	.007
April[b]	8,794	100	3,268	194,460	.233	.260
May	1,118	214	565	34,740	.040	.046
June	2,190	45	552	32,846	.039	.044
July	45	1	17	1,045	.001	.001
August	1	0	[a] 1	61	----------	--------
September	0	0	0	0	----------	--------
October	0	0	0	0	----------	--------
November	45	0	[a] 14	833	.001	.001
December	24	15	15	922	.001	.001
The year	----------	----------	391	280,577	.028	.374

[a] Estimated. [b] April 1–10, inclusive, estimated.

SEEPAGE MEASUREMENTS ALONG MILK RIVER BETWEEN HAVRE AND GLASGOW, MONT., IN 1904.

During August, 1904, a series of seepage measurements were made along Milk River from Havre to Glasgow, Mont., by W. B. Freeman. The river was practically dry along certain stretches, a condition existing not oftener than once in from five to ten years.

The canals in the vicinity of Chinook, noted below, have been in operation about ten years. It is seen that the return water from seepage is very small, the maximum being 0.10 second-foot per mile. These results will be of value in comparison with future measurements as irrigation develops in the valley.

The following table gives the results of measurements:

Seepage measurements along Milk River between Havre and Glasgow, Mont., in 1904.

Date.	Location.	Distance.[a]	Ditch.	River.	Gain or loss.	
					Total.	Per mile.
		Miles.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
August 10	Havre			3.4		
August 9	Fort Belknap canal	20	2.6	2.9	+ 2.1	0.10
August 9	West Fork inflow	26		2.0		
August 9	Paradise canal	8	5.3	3.0	+ 3.4	.10
August 8	Harlem canal	9	1.0	2.3	+ .3	.03
August 8	Indian ditch	22	2.0	1.4	+ 1.1	.05
August 6	Malta	97		1.0	− .4	
August 6	Glasgow	160		[b] 27.5	+26.5	.17

[a] Distances are from point to point, measured along the river.
[b] Includes inflow from northern tributaries, Frenchman and Rock creeks, and other tributaries not measured.

FORT BELKNAP CANAL NEAR CHINOOK, MONT.

Fort Belknap canal is owned by a cooperative company of farmers. It irrigates extensive areas of bottom lands near Chinook, Mont. The station was established June 21, 1903, by L. E. Granke. It is located 1 mile below the head-gates of the canal at the highway crossing. It is reached by driving from Chinook, Mont. The gage is a vertical board fastened to the downstream chord of the wooden bridge. Discharge measurements are made from the wooden highway bridge, to which the gage is attached. The initial point for soundings is a spike 15 feet from the gage on the right end of the downstream hand rail. Distances from the initial point are marked by spikes every 3 feet. Both banks are sloping, and the bed is composed of sand. Bench mark No. 1 is a nail at the base of a large cottonwood tree 300 feet southeast of the gage. Its elevation is 3.91 feet above the zero of the gage and 2,427.8 feet above sea level. Bench mark No. 2 is a nail in a telegraph pole 30 feet northeast of the bridge. This has an elevation of 7.57 feet above the gage zero, or an elevation of 2,431.46 feet above sea level. This gage datum, however, is 0.15 foot higher than that of 1903. The canal carries water only during the irrigating season.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Fort Belknap canal near Chinook, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 9 [a]	A. E. Place	27.0	41.0	2.07	2.34	85
May 19	L. R. Stockman	32.0	55.0	1.36	2.93	75
June 30	Robert Follansbee	33.0	59.0	1.50	3.00	90
August 9	W. B. Freeman	7.8	3.3	.79	.81	2.5

[a] Head-gates being opened during measurement.

Mean daily gage height, in feet, of Fort Belknap canal near Chinook, Mont., for 1904.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	.....	3.70	2.75	12	2.70	1.70	2.20	23	3.80	3.20	1.80
2	.....	3.60	2.80	13	2.80	1.65	2.20	24	3.80	3.20	.....
3	.....	2.30	2.70	14	2.70	1.60	2.20	25	3.80	3.10	.....
4	.....	2.30	2.65	15	2.70	1.60	2.20	26	3.90	3.00	.....
5	.....	2.30	2.60	16	2.70	1.60	2.20	27	3.80	2.90	.....
6	.....	2.30	2.55	17	2.80	3.00	2.25	28	3.80	2.85	.....
7	.....	2.20	2.50	18	2.70	3.20	2.25	29	3.80	2.90	.....
8	.....	2.20	2.40	19	2.90	3.30	2.20	30	3.80	2.80	.....
9	[a] 2.30	2.20	2.40	20	2.80	3.25	2.10	31	3.80	.....	.....
10	2.70	1.80	2.30	21	3.60	3.30	2.00				
11	2.60	1.60	2.20	22	3.70	3.20	1.90				

[a] Canal operated from May 2 to July 23, when it was closed for lack of water.

Rating table for Fort Belknap canal near Chinook, Mont., for irrigation seasons of 1903 and 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.60	18	2.20	40	2.80	70	3.40	100
1.70	21	2.30	45	2.90	75	3.50	105
1.80	24	2.40	50	3.00	80	3.60	110
1.90	28	2.50	55	3.10	85	3.70	115
2.00	31	2.60	60	3.20	90	3.80	120
2.10	35	2.70	65	3.30	95	3.90	125

Curve is well defined only at the extreme upper and lower limits. Curve extended above gage height 3.13 feet.

Estimated monthly discharge of Fort Belknap canal near Chinook, Mont., for 1903 and 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1903.				
June 21 to 30, inclusive	107	87	100	1,983
July 1 to 4, inclusive	92	87	90	714
1904.				
May 9 to 31, inclusive	125	45	91	4,151
June	115	18	61	3,630
July 1 to 23, inclusive	70	24	46	2,098

PARADISE VALLEY CANAL NEAR CHINOOK, MONT.

Paradise Valley canal is owned by a cooperative company of farmers. It irrigates bottom lands several miles east of Chinook, Mont. The station was established in June, 1903, by C. T. Prall. It is located near the South River road, 7 miles east of Chinook, from which place it is reached by driving. The gage is a vertical board driven into the bed of the canal about 500 feet below the head-gates and fastened to a measuring footbridge near the house of the observer, Rudolph Friede. Discharge measurements are made from the above-mentioned footbridge. The initial point for soundings is the "0" on the footbridge at the left bank. The channel is straight, and the section at the station is semicircular. The bed of the canal is composed of mud and sand. This canal carries water only during the irrigating season. Bench mark No. 1 is a spike in the top of a 6 by 6 inch post on the left side of the downstream end of the head-gate. Its elevation above gage datum is 7.29 feet. Bench mark No. 2 is a spike in the southwest side of a 12-inch post 40 feet south of the south end of the dam and 28 paces east of bench mark No. 1. Its elevation above gage datum is 7.38 feet.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Paradise Valley canal near Chinook, Mont., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 18	L. R. Stockman	9.1	0.79	0.82	7.2
June 30	Robert Follansbee	8.7	.60	1.20	5.3
August 9	W. B. Freeman	7.3	.73	1.01	5.3

Mean daily discharge,[a] in second-feet, of Paradise Valley canal near Chinook, Mont., for 1904.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	5.0	6.5	5.0	.....	.....
2	.....	15.0	7.5	5.0	.....	.....
3	.....	8.0	7.5	6.0	.....	.....
4	.....	5.0	8.0	6.0	.....	.....
5	.....	5.0	9.0	6.0	.....	.....
6	.....	7.0	9.0	6.0	.....	.....
7	.....	6.0	9.0	6.0	.....	.....
8	.....	5.0	9.0	5.0	.....	.....
9	.....	2.5	8.0	5.0	.....	.....
10	.....	2.5	8.0	5.0	.....	.....
11	5.5	.5	10.0	5.0	.....	0.5
12	3.0	1.0	10.0	4.0	.....	1.0
13	1.0	1.0	10.0	3.5	.....	.5
14	.0	.0	9.5	3.5	.....	.5
15	8.0	.....	9.5	3.0	.....	.....
16	8.0	.....	7.5	3.0	.....	.....
17	8.0	3.5	3.5	2.5	.....	.5
18	2.5	1.0	4.5	2.5	.....	1.0
19	14.5	1.0	6.5	2.0	.....	2.0
20	16.0	.....	7.5	2.5	.....	2.0
21	11.5	3.5	8.5	1.0	.....	.....
22	6.5	2.5	7.5	1.0	.....	.....
23	5.0	.....	9.5	1.0	.....	.....
24	8.0	5.5	10.0	.5	.....	.....
25	10.5	10.0	10.0	.....	.....	.....
26	13.5	10.0	8.5	.....	.....	.....
27	10.5	10.0	6.5	.....	.....	.....
28	10.0	9.0	6.5	.....	.....	.....
29	8.0	7.5	6.5	.....	.....	.....
30	7.5	7.5	2.5	.....	.....	.....
31	8.0	.....	4.0	.....	.....	.....

[a] No flow during 1904 except as given in the above table.

NOTE.—Owing to the alternate silting up and cleaning out of the canal one curve for the season is impossible. The discharge has been estimated from a series of parallel curves.

Estimated monthly discharge of Paradise Valley canal near Chinook, Mont., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
May 11 to 31, inclusive	16	0	8	333
June	15	0	4	238
July	10	2.5	8	492
August	6	0	3	184
October 11 to 20, inclusive	2	0	1	20

HARLEM CANAL NEAR ZURICH, MONT.

Harlem canal is owned by a cooperative company of farmers. It irrigates a considerable area of bottom lands near Harlem, Mont.

The station was established in June, 1903, by C. T. Prall. It is

located about 500 feet below the head-gates of the canal and about 1 mile southeast of the Great Northern Railroad section house at Zurich, Mont. It is best reached by driving from Harlem or Chinook, Mont. The gage is a vertical board driven into the bed of the canal. The gage is read daily during the irrigating season by John Palm. Discharge measurements are made from a small bridge 2 miles below the gage on the road from Harlem to Cleveland, or by wading near the gage board. The initial point for soundings is a stake driven into the left bank opposite the gage. The bench mark is a spike in the downstream face of the 6 by 8 inch post on the left and on the downstream end of the head-gate. This spike is about 10 inches below the top of the cross piece, and is at an elevation of 11.89 feet above the gage datum. Two bench marks were established at the lower measuring station, No. 1 being a spike in upstream end of bed piece on left abutment 2.10 feet from outside of lower chord. It is 6.62 feet above the gage datum. No. 2 is a spike on west side of south gate post, 26 paces south of right end of bridge. Elevation, 4.44 above gage datum.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Harlem canal near Zurich, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 18	L. R. Stockman	20.6	54.0	0.92	2.62	49.6
July 1	Robert Follansbee	20.0	47.6	.50	1.60	24.0
August 8	W. B. Freeman	7.5	2.5	.40	.58	1.0

Mean daily gage height, in feet, of Harlem canal near Zurich, Mont., for 1904.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	2.60	1.55	0.70	17	2.10	1.90	.90	.55
2	.....	2.85	1.45	.70	18	2.50	2.00	.90	.50
3	.....	2.65	1.30	.60	19	2.50	2.00	.80	.50
4	.....	2.70	1.00	.60	20	2.40	1.85	.80	.50
5	.....	2.65	.90	.60	21	2.20	1.90	.80	.....
6	.....	2.60	.75	.50	22	2.05	1.85	.70	.....
7	.....	2.45	.60	.60	23	2.15	1.80	.70	.....
8	.....	2.30	.60	.60	24	2.35	1.30	.60	.....
9	.....	2.20	.60	.60	25	2.50	1.35	.60	.....
10	.....	2.20	.60	.60	26	2.60	1.40	.55	.....
11	1.80	2.20	.60	.60	27	2.55	1.50	.50	.....
12	1.90	2.20	.60	.60	28	2.50	1.55	.50	.....
13	2.00	2.35	.60	.60	29	2.50	1.65	.60	.....
14	2.10	2.50	.70	.50	30	2.55	1.80	.70	.....
15	2.00	2.00	.70	.50	31	2.60	.....	.70	.....
16	2.00	2.00	.80	.55					

Canal operated April 1 to August 20.

Rating table for Harlem canal near Zurich, Mont., for irrigation seasons of 1903 and 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.60	1	1.30	15	2.00	33	2.70	52
.70	2	1.40	17	2.10	36	2.80	55
.80	4	1.50	20	2.20	39	2.90	57
.90	6	1.60	23	2.30	41	3.00	60
1.00	8	1.70	25	2.40	44		
1.10	10	1.80	28	2.50	47		
1.20	12	1.90	30	2.60	50		

Curve fairly well determined. Curve extended above gage height 2.62 feet.

Estimated monthly discharge of Harlem canal near Zurich, Mont., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
May 11 to 31, inclusive	50	28	41	1,708
June	56	15	35	2,083
July	21	0	4	246
August 1 to 13, inclusive	2	0	1	26

BEAVER CREEK NEAR ASHFIELD, MONT.

The original station was established July 5, 1903, by A. E. Place. It was located at railroad bridge No. 455 of the Great Northern Railroad, one-fourth mile west of Ashfield, Mont. The gage was read once each day by John Borek, and consisted of a vertical board gage in two sections fastened to the left abutment and to some old piles near the channel. Discharge measurements were made from the railroad bridge. The bench mark was a spike in the pile to the left of the upper part of the gage, and was marked "U. S. G. S. B. M." Its elevation above the zero of the gage was 7 feet. This station was discontinued in December, 1903, on account of the influence of the backwater from a dam completed August 2, 1903, about 1 mile below. A new station was established December 31, 1903, by W. B. Freeman, at a point 2½ miles farther upstream, at the Thomas & Gould ranch, and above the influence of the dam. The new station is 18 miles from Malta, Mont. The gage is an inclined 2 by 6 inch plank securely fastened to posts set in the ground at each end, and has a vertical

extension which gives minus readings in very low water. Later tests of the gage rod showed the same to read 0.01 foot too great per foot vertical. Discharge measurements are made from a ½-inch steel cable about 225 yards above the gage. The cable has a span of 100 feet between supports. A car is suspended from the cable, and a tag wire has been installed and marked at intervals of 5 feet. The initial point for soundings is a nail in the cable support on the left bank. The channel is straight for 300 feet above and below the cable. The right bank is sloping and covered with willows and is not liable to overflow. The left bank is steep and is also covered with willows. The stream has a sluggish velocity. The bed of the stream is composed of mud, and there is but one channel. Bench mark No. 1 is the top of a nail driven flush in the top of a 2 by 4 stake 12½ feet south of the gage. Elevation, 11.432 feet above zero of gage. Bench mark No. 2 is the top of a railroad spike driven in the northwest corner of Thomas's house 1 foot above ground. Elevation, 13.346 feet above zero of gage. Gage readings were made during the last year by R. H. Thomas and A. H. Gould.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Bearer Creek near Ashfield, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 6	W. B. Freeman	62	316	1.11	7.15	352
April 7	do	63	337	1.28	7.55	433
April 9 [a]	do	63	471	2.70	10.40	1,272
April 11	do	58	233	1.18	5.76	276
April 14	do	44	74	1.19	2.37	88
May 13	C. C. Babb				—.60	[b] 0.5

[a] Float measurement. [b] Estimated.

Mean daily gage height, in feet, and discharge, in second-feet, of Beaver Creek near Ashfield, Mont., for 1904.

Day.	April.		May.		Day.	April.		May.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1	.....	.....	0.10	5	16	2.20	83	.....	.....
2	.....	.....	.10	5	17	2.40	91	.....	.....
3	.....	.....	.05	4	18	2.20	83	.....	.....
4	.....	.....	.05	4	19	.....	67	.....	.....
5	.....	.....	.00	3	20	1.35	49	.....	.....
6	6.80	338	.05	1	21	1.10	39	.....	.....
7	[a]10.00	1,728	.....	.....	22	.95	33	.....	.....
8	11.65	1,623	.....	.....	23	.85	29	.....	.....
9	10.50	1,278	.....	.....	24	.....	23	.....	.....
10	8.60	708	.....	.....	25	.55	18	.....	.....
11	5.80	278	.....	.....	26	.45	15	.....	.....
12	4.40	194	.....	.....	27	.35	12	.....	.....
13	3.50	140	.....	.....	28	.30	11	.....	.....
14	.....	115	.....	.....	29	.20	8	.....	.....
15	2.45	93	.....	.....	30	.15	6	.....	.....

[a] Reservoir broke above gaging station.

Note.—Creek dry except from April 6 to May 6.

Rating table for Beaver Creek near Ashfield, Mont., from April 6 to May 6, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.05	1	1.20	43	2.50	95	4.60	206
.00	3	1.30	47	2.60	99	4.80	218
.10	5	1.40	51	2.70	103	5.00	230
.20	8	1.50	55	2.80	107	5.50	260
.30	11	1.60	59	2.90	111	6.00	290
.40	14	1.70	63	3.00	115	6.50	320
.50	17	1.80	67	3.20	125	7.00	350
.60	20	1.90	71	3.40	135	7.50	410
.70	23	2.00	75	3.60	146	8.00	528
.80	27	2.10	79	3.80	158	9.00	828
.90	31	2.20	83	4.00	170	10.00	1,128
1.00	35	2.30	87	4.20	182	11.00	1,428
1.10	39	2.40	91	4.40	194		

Curve extended above highest measurement. Above 7 gage height curve is not well determined, and the extreme upper part is determined by one float measurement.

Estimated monthly discharge of Beaver Creek near Ashfield, Mont., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April 6 to 30, inclusive	1,623	6	258	12,793	0.234	0.218
May 1 to 6, inclusive	5	1	4	48	.004	.001

BEAVER CREEK OVERFLOW CHANNEL NEAR BOWDOIN, MONT.

This station was established June 29, 1903, by C. C. Babb. It is located on an overflow channel of Beaver Creek, about 4 miles southeast of the Great Northern Railroad station at Bowdoin, Mont. It is reached best by wagon from Malta, Mont., 12 miles distant. The water supply is partly due to natural drainage of irrigated lands and partly to water wasted over the spillway at the dam above on Beaver Creek. The gage is a vertical board nailed to a cottonwood tree about 100 feet above the cable. It is graduated to tenths of feet and marked with black paint. The gage is read once each day by John Turmell. Discharge measurements are made by means of a cable, car, and tagged wire, and also by wading. The initial point for soundings is the east side of a post on the west or left bank near the wire fence crossing the channel. The channel is straight for 200 feet above the station and for 100 feet below. The stream is sluggish. During high floods both banks will be submerged, as at that time the whole valley is flooded. The bed of the stream at the station forms a small bar covered with weeds and swamp grass. Bench mark No. 1 is a nail in a hub 1 foot south of the back of the gage. Its elevation is 5.79 feet above the zero of the gage and is 2,213.6 feet above sea level. Bench mark No. 2 is a nail in the northwest corner of Turmell's house. Its elevation above the zero of the gage is 17.64 feet. The elevation of these bench marks has been determined from the bench mark at the Malta schoolhouse. Its elevation is based on the elevation of the rail in front of the Great Northern Railroad station at Malta, Mont.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Beaver Creek overflow channel near Bowdoin Mont., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 21	C. C. Babb	.....	42	0.34	4.15	14.1
August 10	.....do	.....	.....	.....	3.30	*a*.2
1904.						
April 6	W. B. Freeman	123	420	1.54	8.40	646
April 7	.....do	132	529	2.72	9.15	1,480
April 9	.....do	128	463	2.03	8.70	942
April 12	.....do	100	276	1.37	7.10	379
April 14	.....do	56	58	.98	4.80	57
April 20	.....do	6	24	1.12	3.68	2.7

a Estimated.

Mean daily gage height, in feet, and discharge in second-feet, of Beaver Creek overflow channel near Bowdoin, Mont., for 1903.

Day.	July.		August.		Day.	July.		August.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
2	.....	.....	3.25	.....	16	3.50	2	.....	.....
3	.....	.....	3.40	1	17	5.80	166	.....	.....
4	.....	.....	3.60	3	18	6.40	249	.....	.....
5	.....	.....	3.50	2	19	5.90	178	.....	.....
6	.....	.....	3.50	2	20	5.40	118	.....	.....
7	2.70	.....	3.45	1	21	4.60	41	.....	.....
8	3.70	4	3.40	1	22	3.70	4	.....	.....
9	3.60	3	3.30	(*a*)	23	3.50	2	.....	.....
10	4.70	49	.....	.....	24	3.40	1	.....	.....
11	5.00	74	.....	.....	25	3.43	1	.....	.....
12	4.50	33	.....	.....	26	3.40	1	.....	.....
13	3.80	5	.....	.....	27	3.36	1	.....	.....
14	3.60	3	.....	.....	28	3.33	.....	.....	.....
15	3.50	2	.....	.....					

a Dry for rest of year.

Mean daily gage height, in feet, and discharge in second-feet, of Beaver Creek overflow channel near Bowdoin, Mont., for 1904.

Day.	April.		Day.	April.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
5	7.00	360	13	5.75	160	21	3.60	3
6	8.40	792	14	4.90	65	22	3.60	3
7	9.30	1,740	15	5.10	84	23	3.60	3
8	8.90	1,092	16	4.45	30	24	3.60	3
9	8.70	952	17	3.90	7	25	3.60	3
10	8.45	816	18	3.70	4	26	3.50	.....
11	8.20	712	19	3.70	4	27	3.40	.....
12	6.85	330	20	3.70	4	28	3.30	.....

Note: Channel dry except April 5–25, inclusive.

Estimated monthly discharge of Beaver Creek overflow channel near Bowdoin, Mont., for 1903 and 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1903.				
July 8 to 27, inclusive	249	1	47	1,864
August 3 to 8, inclusive	3	1	2	24
1904.				
April 5 to 25, inclusive	1,740	3	341	14,204

MUSSELSHELL RIVER NEAR SHAWMUT, MONT.

This station was established August 12, 1902, by S. B. Robbins. It is located at Crawford's ranch, one-eighth mile west of the post-office at Shawmut, Mont., and 25 miles east of Harlowtown, Mont. It was established to determine the amount of water available for irrigation and storage. The gage is a vertical rod, graduated to feet and tenths with nails, and spiked to a cottonwood stump on the right bank of the river about 200 feet north of Crawford's bunk house. The gage is read once each day by Elmer E. Crawford. A cable will be installed, as there is no bridge from which to make discharge measurements. The channel is straight for 250 feet above and 300 feet below the station. The right bank is high and steep and will overflow at extreme high water. The left bank is low and sloping and will overflow at high water. There is one channel at all stages. At extreme high water the banks may overflow, so that the discharge can not be determined accurately, but this location is the best in this vicinity. Bench mark No. 1 is a 30-penny spike in an 18-inch cottonwood tree, below a blaze. This tree stands at the corral fence, 75 feet northeast of the gage rod. The elevation of the bench mark is 5.89 feet above the zero of the gage. Bench mark No. 2 is a 10-penny spike in a 6-inch cottonwood tree, below a blaze. This tree is 60 feet southeast of the gage rod. The elevation of the bench mark is 6.14 feet above the zero of the gage. The barometric elevation of this station is 3,900 feet above sea level.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurement of Musselshell River near Shawmut, Mont., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
November 8	L. R. Stockman	53.4	1.38	1.15	74.0

Mean daily gage height, in feet, of Musselshell River near Shawmut, Mont., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.10			1.37	2.88	2.90	1,30	1.00	0.30	0.65	1.00
2	1.10			1.37	2.78	3.60	1.30	1.00	1.00	.70	1.00
3				1.37	2.68	3.40	1.50	.90	.80	.70	1.00
4				1.87	2.88	3.10	1.50	.90	.60	.75	1.00
5			1.60	2.17	2.78	3.00	1.50	.80	.60	.75	1.00
6				2.17	2.88	2.80	1.40	.80	.60	.80	1.00
7				1.87	2.78	2.70	1.40	.80	.60	.95	1.00
8	.90			1.77	2.58	2.80	1.40	.70	.60	.95	1.00
9	.90			1.67	2.48	2.70	1.40	.70	.60	.95	1.00
10	1.10		1.40	2.27	2.48	2.50	1.60	.70	.50	.95	1.00
11	1.00		1.40	2.84	2.55	2.40	1.70	.60	.50	.95	.85
12	1.10		1.40	2.94	2.55	2.40	1.50	.60	.60	.95	1.00
13	.90		1.40	2.84	2.45	2.30	1.50	.60	.60	.95	
14	1.00		1.40	3.14	2.35	2.20	1.50	.60	.60	.95	
15	1.00		1.40	3.24	2.35	2.10	1.50	.60	.60	.95	
16	1.00		1.40	3.24	2.25	2.00	1.50	.60	.60	1.00	
17	1.00		1.40	2.44	2.35	2.00	1.50	.40	.60	1.00	
18	1.10		1.30	2.34	2.35	1.90	1.50	.40	.60	1.00	
19	1.10		1.30	2.34	2.25	1.90	1.40	.40	.60	1.00	
20	1.20		1.20	2.54	2.55	1.90	1.40	.30	.65	1.00	
21	1.30		1.30	2.61	2.92	1.80	1.30	.30	.65	1.00	
22			1.30	2.81	3.02	1.80	1.30	.30	.65	1.00	
23		1.50	1.20	2.81	3.32	1.70	1.30	.30	.65	1.00	
24		1.60	1.20	2.91	3.62	1.60	1.30	.30	.65	1.00	
25			1.20	2.71	3.92	1.80	1.30	.30	.65	1.00	
26			1.20	2.71	3.72	1.90	1.20	.30	.65	1.00	
27		1.50	1.30	2.71	3.22	1.70	1.20	.30	.65	1.00	
28			1.20	2.91	2.72	1.60	1.10	.30	.65	1.00	
29			1.30	3.01	2.52	1.50	1.00	.30	.65	1.00	
30			1.30	3.21	2.52	1.40	1.00	.30	.65	1.00	
31			1.50		2.62		1.00	.30		1.00	

[a] River frozen January 1 to 7, inclusive, and January 22 to March 9, inclusive.

LITTLE MUDDY RIVER NEAR WILLISTON, N. DAK.

This station was established February 4, 1904, by E. F. Chandler. It is located in Sec. 19, T. 155 N., R. 100 W., the gage in the SW. ¼, the cable in the NE. ¼, about 7 miles by road from Williston, N. Dak. A standard chain gage is attached to a timber projecting horizontally over the stream near the house of the observer, W. O. Hollar, who reads the gage once each day. The length of the chain from the end of the weight to the outer edge of the ring is 22.23 feet. Discharge

measurements are made by means of a cable and car. A barbed wire with galvanized iron tags 10 feet apart is stretched across the stream just above the cable. The initial point for soundings is a point 6 inches behind the top of the cable support at the right bank. The channel is straight for about 600 feet above and 1,700 feet below the station. The current is sluggish. Both banks are high, clean, and do not overflow. The bed of the stream is composed of silt and is fairly permanent. There is but one channel at all stages. The bench mark is a post driven to the surface of the ground under the projecting timber of the chain gage, and marked with a brass-headed nail in the top. Its elevation above the zero of the gage is 2.92 feet.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Little Muddy River near Williston, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 16	E. F. Chandler	115	674	1.31	5.40	885
May 2	do	104	520	.69	4.14	359
May 30	R. Richards	95	289	.21	2.74	61
June 7[a]	E. F. Chandler and E. C. Murphy.	42	30	1.33	2.92	40
July 12[a]	R. Richards	7	5.8	1.96	2.52	11.5
August 10[a]	do	7	5.1	1.66	2.50	8.4
September 13[a]	E. F. Chandler	7	5.0	1.82	2.47	9.

[a] By wading.

Mean daily gage height, in feet, of Little Muddy River near Williston, N. Dak., for 1904.

Day.	Apr.[a]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.9	2.7	2.6	2.4	2.4	2.5	2.6	2.6
2	.....	4.95	2.7	2.6	2.4	2.4	2.5	2.6	2.6
3	5.7	4.8	2.65	2.6	2.4	2.4	2.5	2.6	2.6
4	5.8	4.4	2.7	2.6	2.4	2.4	2.5	2.6	(b)
5	6.2	4.2	2.8	2.6	2.4	2.4	2.5	2.6	.....
6	6.6	4.05	2.9	2.6	2.4	2.4	2.5	2.6	.....
7	7.7	3.9	2.9	2.6	2.4	2.4	2.5	2.6	.....
8	7.6	3.6	2.8	2.6	2.4	2.4	2.5	2.6	.....
9	7.6	3.35	2.7	2.6	2.4	2.4	2.5	2.6	.....
10	8.2	3.25	2.7	2.6	2.5	2.4	2.5	2.6	.....
11	10.3	3.3	2.8	2.5	2.5	2.4	2.5	2.6	.....
12	8.4	3.35	3.05	2.5	2.5	2.4	2.5	2.6	.....
13	10.0	3.4	2.85	2.5	2.5	2.5	2.5	2.6	.....

[a] Gage heights April 3 to 15, inclusive, estimated.
[b] River frozen during January, February, March, and December

Mean daily gage height, in feet, of Little Muddy River near Williston, N. Dak., for 1904— Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
14	9.0	3.3	2.75	2.5	2.5	2.5	2.5	2.6	.....
15	8.4	3.2	2.7	2.5	2.5	2.5	2.5	2.6	.....
16	5.4	3.15	2.7	2.5	2.5	2.5	2.5	2.6	.....
17	5.25	3.05	2.7	2.5	2.5	2.5	2.5	2.6	.....
18	5.1	3.0	2.7	2.5	2.5	2.5	2.5	2.6	.....
19	5.2	2.9	2.65	2.5	2.4	2.5	2.5	2.6	.....
20	5.15	2.9	2.6	2.5	2.4	2.5	2.5	2.6	.....
21	5.0	2.9	2.6	2.5	2.4	2.5	2.5	2.6	.....
22	5.0	2.8	2.6	2.5	2.4	2.5	2.5	2.6	.....
23	4.8	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
24	4.65	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
25	4.5	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
26	4.6	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
27	4.95	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
28	5.35	2.8	2.6	2.5	2.5	2.5	2.5	2.6	.....
29	5.25	2.7	2.6	2.5	2.5	2.5	2.5	2.6	.....
30	5.1	2.7	2.6	2.5	2.5	2.5	2.6	2.6	.....
31	.....	2.7	.....	2.4	2.4	.....	2.6	.....	.....

Rating table for Little Muddy River near Williston, N. Dak., from February 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.40	6	3.40	137	4.30	423	5.20	794
2.50	10	3.50	162	4.40	461	5.30	839
2.60	16	3.60	189	4.50	500	5.40	885
2.70	23	3.70	218	4.60	539	5.50	932
2.80	32	3.80	249	4.70	579	5.60	980
2.90	43	3.90	281	4.80	620	5.70	1,030
3.00	57	4.00	315	4.90	662	5.80	1,082
3.10	74	4.10	350	5.00	705	5.90	1,135
3.20	93	4.20	386	5.10	749	6.00	1,189
3.30	114						

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is fairly defined between gage heights 2.4 feet and 5.4 feet. This table has been extended beyond these limits. Discharges for gage heights above 6 feet have been estimated.

Estimated monthly discharge of Little Muddy River near Williston, N. Dak., for 1904.

[Drainage area, 800 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April (3–30)	4,340	500	1,513	84,030	1.89	1.97
May	684	23	163	10,020	.204	.235
June	66	16	24.6	1,464	.031	.035
July	16	6	11.8	726	.015	.017
August	10	6	8.2	504	.010	.012
September	10	6	8.4	500	.010	.011
October	16	10	10.4	640	.013	.015
November	16	16	16.0	952	.020	.022
The period				98,840		

YELLOWSTONE RIVER NEAR LIVINGSTON, MONT.

This station was established May 2, 1897. It is located at Carter's bridge, 5 miles south of Livingston, Mont., at the mouth of the lower canyon. A vertical rod was first installed, but was replaced by a wire gage, which is located on the lower side of the east span. The length of the wire from the end of the weight to the marker was 21.76 feet. This gage in turn was replaced in April, 1904, by a standard chain gage having the same datum, but a chain length 20.73 feet. The gage is read once each day by W. O. Cowan. Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is marked on the guard rail, 2 feet east of the center of the northwest pier. The channel is straight for about 300 feet above and for 250 feet below the station. The right bank is low, and at high stages a part of the water escapes through a slough on that side and has to be measured separately. The left bank is high and rocky and will not overflow. The current velocity is swift, and at high water it is difficult to keep the meter submerged without the aid of a stay rope. On January 1, 1903, the gage and the datum were lowered 3 feet, increasing all subsequent readings by that amount. Bench mark No. 1 is the head of the 2-inch nut on the center pin at the foot of the end diagonal of the upstream truss at the east pier. Its elevation is 13.44 feet above the old and 17.60 feet above the new datum. Bench mark No. 2 is a white paint mark on the corner of the top of the shoe at the foot of the batter post on the east end of the upstream side of the bridge. The batter post is marked "B. M. 14.20, U. S. G. S." in white paint. It is also marked "17.20" in red paint. Its elevation is 14.20 feet above the old and 17.20 feet above the new gage datum.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Yellowstone River near Livingston, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 23	A. E. Place	190	642	3.44	2.88	2,206
May 16	W. B. Freeman	184	1,009	4.91	4.77	4,957
June 2	do	274	2,002	8.70	8.42	17,418
June 23	do	278	2,138	9.62	8.94	20,573
June 25	do	278	1,927	7.80	8.02	15,034
July 11	do	274	1,687	7.55	7.16	12,736
July 26	do	189	1,250	6.14	5.78	7,677
August 20	do	184	894	4.62	4.19	4,130
September 13	do	181	738	3.79	3.34	2,794
October 26	L. R. Stockman	171	577	3.30	2.54	1,904

Mean daily gage height, in feet, of Yellowstone River near Livingston, Mont., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.60	2.00	2.10	3.75	8.28	8.15	5.42	3.90	2.87	2.50	2.10
2	1.60	1.65	1.95	2.05	3.70	8.28	8.15	5.38	3.80	2.87	2.45	2.15
3	1.65	1.65	1.90	2.05	3.75	7.98	8.05	5.12	3.80	2.82	2.40	2.20
4	1.60	1.75	1.90	2.15	3.90	7.48	8.05	5.12	3.60	2.72	2.40	2.25
5	1.65	1.95	1.95	2.15	4.25	7.48	7.95	5.02	3.60	2.72	2.40	2.15
6	1.60	1.80	1.95	2.15	4.20	7.68	7.75	4.92	3.60	2.72	2.40	1.70
7	1.55	1.55	2.05	2.20	4.25	8.18	7.45	4.82	3.55	2.72	2.35	1.90
8	1.65	(a)	2.15	2.15	4.10	8.13	7.30	4.72	3.50	2.72	2.30	2.00
9	1.75	(a)	2.35	2.05	3.75	8.08	7.30	4.72	3.50	2.72	2.30	2.00
10	1.70	(a)	2.05	2.25	3.90	8.48	7.15	4.72	3.40	2.72	2.30	2.50
11	1.80	(a)	2.05	2.45	4.30	8.48	7.15	4.72	3.40	2.72	2.25	2.10
12	1.85	1.85	2.10	2.55	4.10	8.48	7.15	4.68	3.40	2.72	2.25	1.90
13	1.85	1.75	2.05	2.60	4.15	8.48	7.45	4.62	3.35	2.72	2.20	1.90
14	1.90	1.85	2.10	2.75	4.30	8.48	7.15	4.62	3.30	2.67	2.20	2.00
15	1.90	(a)	2.10	2.85	4.70	8.68	6.80	4.42	3.30	2.67	2.20	2.00
16	1.95	2.00	2.05	2.85	4.75	8.68	6.65	4.32	3.20	2.67	2.20	1.95
17	1.95	1.85	1.95	2.75	4.75	8.78	6.55	4.32	3.15	2.77	2.20	2.00
18	1.90	1.75	2.00	2.70	b5.25	8.88	6.35	4.32	3.15	2.77	2.20	2.00
19	1.85	1.55	2.10	2.75	6.20	8.88	6.25	4.32	3.15	2.67	2.20	2.00
20	1.80	1.75	2.15	3.05	6.80	8.88	6.25	4.22	3.10	2.67	2.20	2.00
21	1.65	1.85	2.10	3.05	7.80	8.73	6.20	4.12	3.10	2.67	2.20	2.00
22	1.55	1.90	1.80	2.95	8.20	8.78	6.15	4.12	3.10	2.62	2.20	2.00
23	1.60	1.95	1.80	2.85	8.20	8.88	6.05	4.08	3.05	2.62	2.15	1.95
24	1.65	1.90	1.80	2.90	8.90	8.78	6.10	3.92	3.00	2.57	2.15	1.80
25	(a)	1.90	2.05	2.80	8.20	7.98	5.95	3.92	3.00	2.57	2.15	1.70
26	1.95	2.00	1.95	2.90	7.20	7.78	5.85	3.82	3.00	2.52	2.10	1.70
27	1.75	1.95	2.05	3.20	6.70	7.78	5.75	3.82	3.00	2.60	2.10	1.30
28	1.85	1.95	2.15	3.65	7.00	7.78	5.75	3.82	3.00	2.60	2.10	1.30
29	1.85	2.00	2.15	3.90	7.60	7.98	5.75	3.92	3.00	2.50	2.20	1.70
30	(a)	.....	2.15	3.80	8.20	8.18	5.55	4.02	3.00	2.50	2.20	2.00
31	1.65	.....	2.15	.....	8.20	.....	5.45	4.02	.....	2.50	.....	2.10

a River frozen at gage. b River running through side channel May 18 to August 6.

Rating table for Yellowstone River near Livingston, Mont., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
1.30	900	2.60	1,970	3.90	3,615	6.40	9,645
1.40	950	2.70	2,070	4.00	3,785	6.60	10,305
1.50	1,010	2.80	2,170	4.20	4,125	6.80	10,980
1.60	1,080	2.90	2,270	4.40	4,465	7.00	11,660
1.70	1,160	3.00	2,380	4.60	4,820	7.20	12,400
1.80	1,250	3.10	2,490	4.80	5,220	7.40	13,190
1.90	1,340	3.20	2,600	5.00	5,700	7.60	13,990
2.00	1,430	3.30	2,720	5.20	6,195	7.80	14,810
2.10	1,520	3.40	2,850	5.40	6,695	8.00	15,700
2.20	1,610	3.50	2,980	5.60	7,210	8.50	18,050
2.30	1,700	3.60	3,125	5.80	7,760	9.00	20,400
2.40	1,790	3.70	3,280	6.00	8,350		
2.50	1,880	3.80	3,445	6.20	8,985		

The above table is applicable only for open-channel conditions. It is based upon 10 discharge measurements made during 1904. It is well defined between gage heights 3 feet and 9 feet. The table has been extended beyond these limits. Above 8 feet the curve is a tangent, the difference being 470 per tenth.

Estimated monthly discharge of Yellowstone River near Livingston, Mont., for 1904.

[Drainage area, 3,580 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	1,385	1,045	1,211	74,462	0.338	0.390
February	1,430	1,045	1,256	72,246	.351	.378
March	1,745	1,250	1,460	89,772	.408	.470
April	3,615	1,475	2,102	125,078	.587	.655
May	19,930	3,280	8,446	519,324	2.359	2.720
June	19,930	13,590	17,291	1,028,886	4.830	5.389
July	16,405	6,820	11,069	680,607	3.092	3.565
August	6,695	3,445	4,604	283,089	1.286	1.483
September	3,615	2,380	2,749	163,577	.768	.857
October	2,220	1,880	2,030	124,820	.567	.654
November	1,880	1,520	1,653	98,360	.462	.515
December	1,880	900	1,388	85,345	.388	.447
The year	19,930	900	4,605	3,345,566	1.286	17.523

YELLOWSTONE RIVER NEAR BILLINGS, MONT.

This station was established May 29, 1904, by R. S. Stockton. It is located at the county wagon bridge, about 2 miles east of Billings, Mont., and 200 feet below the bridge of the Northern Pacific Railway. A standard chain gage is attached to the bridge, near the middle of the first span from the west bank. The length of the chain from the end of the weight to the marker is 27.95 feet. Marker is a copper-wire index. The gage is read twice each day by James Dickie. Discharge measurements are made from the lower side of the bridge. The bridge is well constructed of wood and has three spans resting on steel-jacketed concrete piers. The initial point for soundings is at the west end of the bridge. Each 10-foot point is marked on the bridge timbers. The channel is straight for about 200 feet above and 400 feet below the station, and the current is swift. The right bank is a low gravel bar which rises to above high water. Above the bridge is the headgate for a small ditch. The left bank is low, sandy, and overflows in extreme high water. The bed of the stream is composed of gravel, free from vegetation. There is but one channel at all stages, broken by two piers. The masonry piers of the railway bridge, 200 feet upstream; an island, 400 feet downstream; and the height of the bridge above the water, about 20 feet, affect the accuracy of measurements. Bench mark No. 1 is on the top of the third course of stones in the left abutment of the bridge of the Northern Pacific Railway. Its elevation is 18.99 feet above the zero of the gage. Bench mark No. 2 is the top of a nail on the end of the second bent from the west end of the wagon bridge, on the downstream end of the bent sill. Its elevation is 18.21 feet above the zero of the gage.

A river gage is also maintained by the Department of Agriculture at the second county bridge above, about 4 miles west of the Geological Survey station.

Observations were made at this station since the end of May, 1904, under the direction of C. C. Babb, district engineer.

Discharge measurements of Yellowstone River near Billings, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 10	R. S. Stockton	462	4,719	4.64	8.40	21,907
July 29	do	419	3,230	3.80	6.05	12,289
August 18	W. B. Freeman	332	2,542	3.53	4.33	8,963
September 16	do	320	2,069	2.46	2.90	5,086
September 27	R. S. Stockton	335	1,974	2.18	2.53	4,305
October 21	L. R. Stockman		1,838	2.24	2.53	4,124

Mean daily gage height, in feet, of Yellowstone River near Billings, Mont., for 1904.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	9.20	8.10	5.95	4.45	2.30	2.20	1.90
2	.....	9.00	9.05	5.15	4.10	2.30	2.10	1.90
3	.....	.....	9.15	5.05	3.75	2.30	2.10	1.90
4	.....	8.40	9.00	.....	3.65	2.30	2.10	(a)
5	.....	8.10	8.75	4.85	3.35	2.30	2.00	(a)
6	.....	8.05	8.60	4.70	3.35	2.30	2.00	(a)
7	.....	8.60	8.85	4.55	3.35	2.30	2.00	(a)
8	.....	8.00	8.80	4.50	3.35	2.40	2.00	(a)
9	.....	9.40	8.50	4.45	3.25	2.30	2.00	(a)
10	.....	9.60	8.50	4.45	3.25	2.30	2.00	(a)
11	.....	9.00	8.30	4.45	3.05	2.40	2.00	1.60
12	.....	8.10	8.20	4.60	3.05	2.40	2.10	1.60
13	.....	9.00	8.35	4.80	3.00	2.40	2.10	1.70
14	.....	9.10	8.20	4.70	2.95	2.40	2.20	1.70
15	.....	9.40	8.05	4.55	2.95	2.50	2.20	1.70
16	.....	9.60	7.70	4.35	2.85	2.70	2.20	1.70
17	.....	9.85	7.35	4.35	2.85	2.50	2.00	1.70
18	.....	10.00	6.85	4.40	2.75	2.50	2.00	1.70
19	.....	10.25	6.40	4.15	2.60	2.50	2.00	1.70
20	.....	10.60	6.35	4.10	2.55	2.40	2.00	1.70
21	.....	10.50	6.40	4.05	2.65	2.40	2.00	1.70
22	.....	10.30	6.40	4.00	2.65	2.30	2.00	1.70
23	.....	10.40	6.40	3.75	2.65	2.30	1.95	1.70
24	.....	10.05	6.55	3.65	2.75	2.30	1.90	1.60
25	.....	9.50	6.45	3.65	2.75	.....	1.90	1.60
26	.....	9.00	6.40	3.55	2.65	2.30	1.90	1.60
27	.....	8.30	6.10	3.55	2.55	2.30	1.90	1.60
28	.....	8.30	5.85	3.55	2.45	2.20	1.90	1.60
29	7.75	8.40	6.10	4.15	2.45	2.20	1.90	1.60
30	8.10	8.80	6.05	4.05	2.45	2.20	1.90	1.60
31	9.00	.....	6.05	4.55	.....	2.20	.....	1.60

a River frozen.

Rating table for Yellowstone River near Billings, Mont., from May 29 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.60	2,740	3.10	5,350	4.60	8,770	7.00	15,690
1.70	2,900	3.20	5,560	4.70	9,020	7.20	16,450
1.80	3,060	3.30	5,770	4.80	9,270	7.40	17,230
1.90	3,225	3.40	5,990	4.90	9,520	7.60	18,040
2.00	3,390	3.50	6,210	5.00	9,770	7.80	18,900
2.10	3,555	3.60	6,440	5.20	10,290	8.00	19,840
2.20	3,720	3.70	6,670	5.40	10,810	8.20	20,820
2.30	3,890	3.80	6,900	5.60	11,330	8.40	21,800
2.40	4,060	3.90	7,130	5.80	11,860	8.60	22,780
2.50	4,230	4.00	7,360	6.00	12,400	8.80	23,760
2.60	4,410	4.10	7,590	6.20	12,960	9.00	24,740
2.70	4,590	4.20	7,820	6.40	13,550	9.50	27,190
2.80	4,770	4.30	8,050	6.60	14,210	10.00	29,640
2.90	4,960	4.40	8,290	6.80	14,940	10.50	32,090
3.00	5,150	4.50	8,530				

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1904. It is fairly well defined between gage heights 2.5 feet and 8.4 feet. Beyond these limits the table is only approximate. Above gage height 8 feet the rating curve is a tangent, the difference being 490 per tenth.

Estimated monthly discharge of Yellowstone River near Billings, Mont., for 1904.

[Drainage area, 11,180 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
June	32,580	19,840	25,972	1,545,441	2.323	2.592
July	25,475	11,995	18,088	1,112,188	1.618	1.865
August	12,265	6,325	8,257	507,703	.738	.851
September	8,410	4,145	5,240	311,802	.469	.523
October	4,590	3,720	3,973	244,290	.355	.409
November	3,720	3,225	3,420	203,504	.306	.341
December	3,225	2,740	2,906	178,683	.260	.300
The period				4,103,611		

YELLOWSTONE RIVER AT GLENDIVE, MONT.

This station, established in 1893 by the United States War Department, was transferred to the Department of Agriculture, where daily records of the gage are kept.

When a study of the lower Yellowstone Valley was begun in 1903 this station was taken up by the United States Geological Survey, whose records begin August 1, 1903. It is located at the steel highway bridge leading northward out of Glendive, about one-fourth mile from the post-office. The gage is of the wire type and is fastened to the upstream hand rail of the second span, about 200 feet from its right end. The graduations are marked upon the hand rail. The marker is an adjustable pointer near the handle. The distance from the marker to the bottom of the weight is 48.99 feet. This gage was destroyed October 24. One month later a standard chain gage, having the same datum as the old wire gage, was put in its place. The gage is read daily by H. A. Sample, of Glendive, Mont. The measurements are made from the downstream hand rail of the bridge, upon which the distances are painted. The initial point is over the southeast cement-filled iron pier at the right. The bridge spans the channel in four truss spans of about 300 feet each. The channel above is straight for about 500 feet and below for the same distance. The water, especially at high stages, is very swift. The right bank is high and of clay and gravel. Being riprapped for some distance, it is not subject to inundation. The left is a low bank, beyond which are sandy flats covered with trees and brush and extending to the hills, 1 mile distant. These are liable to become submerged. At low water an island becomes visible between the third and fourth spans from the right, and at flood stages water finds it way through a slough traversing the above-mentioned flats. The bed is of sand and clay and liable to shift with every flood. Old piling and cribwork, remains of a former bridge, obstruct the channel on the upstream side. Bench mark No. 1 is a point on the surface of the cement at the northwest corner of the girder on the pier under Station "O." Its elevation is 26.26 feet above gage datum and 2,060.6 feet above sea level. Bench mark No. 2 is the top of the west rail of the Northern Pacific track at the right end of the bridge. Its elevation is 30.19 feet above gage datum. A temporary bench mark is the center of the pulley of the old wire gage, which is fastened to the hand rail and is 41.96 feet above the gage zero. The elevation above sea level of the bench marks was determined from the Northern Pacific Railway elevation of the rail at Terry, Mont. This is 2,242 feet above sea level. The gage readings from 1897 to the establishment of the Geological Survey wire gage were referred to a "T" on the top of the southeast anchor bolt in the south caisson at the east end of the bridge. Its

elevation when established was 25.08 feet above gage datum. The gage heights up to April 8, 1899, were read from a wire gage. On this date the gage was carried away by ice and the gage heights during the remainder of 1899 were determined by measuring down from the bench mark on the anchor bolt. A new bridge was erected in 1901, and it is not known whether this bench mark was disturbed or not.

The observations at this station during 1904 have been made under the direction of C. C. Babb, district engineer.

Discharge measurements of Yellowstone River at Glendive, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 22	A. E. Place	649	3,617	2.96	2.44	10,718
May 17	W. B. Freeman	738	4,631	3.32	4.11	15,396
June 1	W. B. Freeman and E. C. Murphy.	760	7,260	5.78	7.42	41,982
June 24	W. B. Freeman	1,035	9,722	6.71	9.21	65,224
July 12	do	760	6,958	5.37	7.02	37,364
July 25	do	744	5,569	4.16	5.28	23,162
August 19	do	732	4,117	2.98	3.35	12,250
September 19	do	721	2,917	2.33	1.89	6,792
October 22	L. R. Stockman	727	2,787	2.32	1.64	6,474

Mean daily gage height, in feet, of Yellowstone River at Glendive, Mont., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.10	4.60	5.20	11.90	3.40	7.40	7.00	5.10	2.85	1.50	.....	0.75
2	5.10	4.60	5.20	7.90	3.60	8.80	7.20	4.90	3.35	1.50	.....	1.15
3	5.00	4.60	5.20	6.70	3.60	8.50	7.70	4.70	3.95	1.50	.....	.95
4	5.00	4.60	5.20	6.00	3.60	9.60	8.20	4.50	3.55	1.40	.....	.85
5	5.00	4.60	5.90	5.50	3.70	8.40	8.20	4.40	3.15	1.30	.....	4.45
6	5.00	4.60	6.50	4.80	3.80	8.40	8.20	4.20	2.95	1.30	.....	[b]6.05
7	5.10	4.60	6.60	4.00	4.40	7.90	7.50	4.00	2.85	1.30	.....	5.75
8	5.10	4.60	6.80	3.40	4.90	7.30	7.50	4.00	2.75	1.30	.....	5.65
9	5.10	4.60	6.80	3.00	4.90	7.30	7.20	3.90	2.65	1.30	.....	5.65
10	5.10	4.60	7.00	2.90	4.90	7.80	7.10	3.80	2.55	1.30	.....	5.55
11	5.10	4.60	9.90	2.70	4.90	7.80	7.30	3.70	2.45	1.30	.....	5.55
12	5.10	4.60	10.60	2.20	4.50	8.10	7.00	3.60	2.45	1.30	.....	5.55
13	5.10	4.60	10.00	2.20	4.30	8.50	7.00	3.50	2.35	1.30	.....	5.45
14	5.10	4.60	8.90	2.20	4.30	8.60	6.90	3.50	2.15	1.30	.....	5.35
15	5.10	4.60	8.40	2.50	4.20	8.20	6.90	3.70	2.05	1.30	.....	5.15
16	5.10	4.60	8.00	2.50	4.20	8.10	7.00	3.70	2.05	1.30	.....	5.10
17	5.10	4.60	7.70	2.60	4.10	8.20	6.80	3.50	1.95	1.40	.....	5.10
18	5.10	4.60	7.70	2.80	4.30	8.40	6.50	3.50	1.95	1.50	.....	5.10

[a] River frozen from January 1 to March 31, inclusive; gage heights to top of ice. Thickness of ice from January 1 to 17, inclusive, 13 inches; from January 18 to 26, inclusive, 14 inches; from January 27 to March 31, inclusive, 20 inches.

[b] River frozen; readings to top of ice for remainder of month.

Mean daily gage height, in feet, of Yellowstone River at Glendive, Mont., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
19	5.10	4.60	7.50	2.90	4.40	8.80	6.30	3.40	1.85	2.10	.....	5.10
20	5.10	4.60	7.50	2.60	4.50	9.20	6.00	3.30	1.85	1.80	.....	4.90
21	5.10	4.60	7.20	2.60	4.70	9.30	5.70	3.30	1.85	1.80	.....	5.00
22	5.10	4.60	7.20	2.60	6.00	9.50	5.50	3.30	1.75	1.70	.....	5.00
23	5.10	4.60	7.00	2.70	7.10	10.20	5.40	3.30	1.75	1.60	.....	5.00
24	5.10	4.60	7.00	3.00	7.90	9.20	5.30	3.20	1.65	(a)	.....	4.60
25	5.10	4.60	7.00	3.50	8.80	9.20	5.30	3.20	1.65	.....	.....	5.10
26	5.10	4.60	7.00	4.50	9.00	9.10	5.30	3.10	1.65	.....	.....	5.20
27	5.10	4.60	7.00	3.70	9.30	9.10	5.40	2.90	1.65	.....	.....	4.50
28	5.10	4.80	7.00	3.50	8.90	8.00	5.40	2.80	1.55	.....	.....	4.40
29	5.00	5.00	5.50	3.10	7.90	7.50	5.20	2.60	1.55	.....	0.65	4.30
30	4.90	.....	5.90	2.90	7.50	7.20	5.20	2.60	1.45	.....	.65	4.30
31	4.80	.....	8.40	.....	7.20	.....	5.20	2.60	.....	.....	.....	4.40

(a) Gage broken. Reestablished November 29.

Rating table for Yellowstone River at Glendive, Mont., from April 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.20	5,625	2.60	9,020	3.90	14,450	6.40	31,090
1.30	5,750	2.70	9,380	4.00	14,960	6.60	32,930
1.40	5,900	2.80	9,760	4.20	16,010	6.80	34,850
1.50	6,075	2.90	10,150	4.40	17,100	7.00	36,900
1.60	6,275	3.00	10,550	4.60	18,230	7.20	39,150
1.70	6,500	3.10	10,950	4.80	19,400	7.40	41,580
1.80	6,750	3.20	11,360	5.00	20,610	7.60	44,100
1.90	7,000	3.30	11,770	5.20	21,890	7.80	46,700
2.00	7,250	3.40	12,190	5.40	23,220	8.00	49,300
2.10	7,510	3.50	12,610	5.60	24,600	8.50	55,800
2.20	7,780	3.60	13,040	5.80	26,070	9.00	62,300
2.30	8,060	3.70	13,490	6.00	27,650	9.50	68,800
2.40	8,360	3.80	13,960	6.20	29,330	10.00	75,300
2.50	8,680						

The above table is applicable on.y for open-channel conditions. It is based upon 12 discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.4 feet and 9.2 feet. Above gage height 8.0 feet the rating curve is a tangent, the difference being 1,300 per tenth.

Estimated monthly discharge of Yellowstone River at Glendive, Mont., for 1903 and 1904.

[Drainage area, 66,090 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
March 16 to 31, inclusive	20,610	15,480	17,550	556,958	0.266	0.158
April	39,150	4,600	6,208	369,343	.094	.105
May	22,550	4,700	10,775	664,066	.163	.188
June	62,300	10,550	40,594	2,415,629	.614	.685
July	61,000	16,550	28,089	1,726,818	.425	.490
August	30,200	7,780	14,012	861,564	.212	.244
September	10,150	6,075	7,737	460,384	.117	.130
October	7,510	5,900	6,860	421,805	.104	.120
November 1 to 15, inclusive	5,900	5,750	[a] 5,750	339,471	.087	.097
December	.....	.....	[a] 5,700	350,479	.086	.099
The period	.....	.....	.....	8,166,517	.....	.....
1904.						
January	.....	.....	[a] 5,700	350,479	.086	.099
February	.....	.....	[a] 5,700	327,868	.086	.093
March	.....	.....	[a] 5,700	350,479	.086	.099
April 2 to 30, inclusive[b]	48,000	7,780	[b] 13,936	829,250	.211	.235
May	66,200	12,190	27,002	1,660,288	.409	.472
June	77,900	39,150	54,882	3,265,706	.830	.926
July	51,900	21,890	33,500	2,059,835	.507	.584
August	21,240	9,020	12,698	797,371	.196	.226
September	14,705	5,985	8,273	492,278	.125	.139
October 1 to 23, inclusive	7,510	5,750	.....	.....	.....	.....
December 1 to 5[c]	.....	.....	7,710	76,463	.117	.022
The period	.....	.....	.....	10,210,017	.....	.....

[a] Estimated by C. C. Babb.
[b] Mean for 29 days taken as mean for the month.
[c] River frozen December 6 to 31.

PRYOR CREEK AT HUNTLEY, MONT.

This station was established August 6, 1904, by R. S. Stockton. It is located at Huntley, 13 miles from Billings, Mont. A plain rod gage, graduated to feet and tenths, is placed vertically at the right bank, about 200 feet south of the Northern Pacific Railway station. It is read twice

each day by J. W. Day. Measurements at present are made by wading at a point 50 yards above the gage. Bench mark No. 1 is the top of rail of Northern Pacific Railway Company's track in front of the operator's window. Its elevation is 14.517 feet above the zero of the gage. Bench mark No. 2 is a nail in a pile at the foot of large tree on east side of the creek opposite the station agent's house and post-office. Its elevation is 11.462 feet above the zero of the gage. Bench mark No. 3 is a spike driven into the root of a large tree 100 feet southwest of the water-tank and 150 feet north of the section house. The tree is 40 feet east of the track. The elevation of bench mark No. 3 is 12.787 feet above the zero of the gage. The zero of the gage is 3,012.483 feet above sea level.

Observations at the station since August, 1904, were made under the direction of C. C. Babb, district engineer.

Discharge measurements of Pryor Creek at Huntley, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
August 6[a]	R. S. Stockton		6	1.00	1.00	6
September 17	W. B. Freeman	18	10	1.40	1.25	14

[a] Float measurement.

Mean daily gage height, in feet, of Pryor Creek at Huntley, Mont., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1.25	1.25	1.45	1.90	17	1.00	1.30	1.40	1.70	1.55
2		1.30	1.30	1.50	1.85	18		1.30	1.40	1.60	1.45
3		1.30	1.30	1.55	1.80	19	1.05	1.30	1.40	1.55	1.60
4		1.25	1.30	1.65	1.85	20	1.08	1.30	1.40	1.55	1.55
5		1.20	1.40	1.55	1.75	21	1.10	1.30	1.50	1.55	1.55
6		1.20	1.40	1.60	1.65	22	1.10	1.30	1.50	1.60	1.55
7	1.00	1.20	1.40	1.45	1.60	23	1.10	1.30	1.50	1.65	1.45
8	1.00	1.20	1.40	1.50	1.65	24	1.15	1.30	1.60	1.55	1.55
9	1.00	1.20	1.40	1.55	1.55	25	1.20	1.30	1.45	1.50	1.60
10	1.00	1.20	1.40	1.45	1.80	26	1.25	1.30	1.55	1.60	1.65
11	1.00	1.20	1.40	1.50	1.65	27	1.20	1.25	1.45	1.50	1.55
12	1.18	1.20	1.45	1.45	1.60	28	1.20	1.30	1.55	1.55	1.65
13	1.10	1.20	1.45	1.50	1.55	29	1.20	1.30	1.55	1.65	1.60
14	1.08	1.20	1.50	1.45	1.50	30	1.10	1.25	1.50	1.95	1.60
15	1.05	1.30	1.50	1.30	1.50	31	1.15		1.55		1.50
16	1.05	1.30	1.40	1.70	1.45						

BIGHORN RIVER NEAR THERMOPOLIS, WYO.

This station was established on May 28, 1900, by A. J. Parshall. It was located about a half mile northeast of Thermopolis, at the ferry crossing the river. The gage used during 1900 was a horizontal rod

extending out over the water and fastened to posts firmly set in the ground, with the usual wire attachments. The bench mark was the head of a nail driven in a stake set in the ground 1 foot south of the post to which the gage rod was fastened, 2.58 feet below the gage frame. Its elevation was 6.50 feet above gage datum. It has been destroyed.

In 1901 a new gage with relative heights, the same as that in use in 1900, was painted on the lower center pier of the recently constructed iron bridge, which is located 400 or 500 feet upstream from the former station. In March, 1903, a new gage, serving as a bench mark, and for the observer's use at times of high water, was painted on the lower pier of the bridge on the right bank of the river. This gage is reached by the water only when it is at a height of 3 feet above datum. It will enable the observer to read heights of high water more accurately than can be done on the gage, which is in the center of the stream and is exposed to the force of the current, causing a rise and fall of several inches on the gage. The channel is straight above and below the station. Both banks are high and not subject to overflow. The bed of the stream is composed of rock and gravel. It shifts very little from year to year. Measurements, which were formerly made from a ferryboat, are now made from the bridge. The gage is read daily by V. S. Grout.

The observations at this station during 1904 have been made under the direction of A. J. Parshall, resident hydrographer.

Discharge measurements of Bighorn River near Thermopolis, Wyo.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 25	A. J. Parshall	94	198	1.46	0.41	290
June 19	V. S. Grout	262	1,944	6.66	7.25	12,940
June 22	do	268	2,115	6.73	7.90	14,240
July 11	A. J. Parshall	261	1,247	5.71	4.60	7,117
July 12	do	262	1,270	5.88	4.70	7,467
July 17	V. S. Grout	251	1,088	5.63	4.00	6,130
July 28	do	244	984	5.09	3.50	5,008
August 3	do	244	807	4.90	3.00	3,941
August 11	do	244	681	4.23	2.50	2,878
August 26	do	225	548	3.80	2.00	2,084
November 24	A. J. Parshall	166	306	1.43	.70	438

Mean daily gage height, in feet, of Bighorn River near Thermopolis, Wyo., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.4	1.7	5.1	5.05	3.05	2.45	1.1
2	.4	1.6	5.5	5.35	3.05	2.1	1.0
3	.4	1.5	6.0	5.1	3.00	1.95	1.0
4	.3	1.85	5.75	4.95	2.85	1.9	1.1
5	.25	1.9	5.55	5.25	2.75	2.0	1.15
6	.35	1.75	4.45	5.65	2.75	1.95	1.2
7	.5	1.95	4.9	5.3	2.7	1.85	1.1
8	.6	2.0	5.55	4.9	2.65	1.7	1.1
9	.7	1.95	6.05	4.65	2.6	1.7	1.2
10	.7	2.05	6.3	4.5	2.6	1.6	1.2
11	.65	1.85	6.0	4.6	2.5	1.5	1.2
12	.6	1.7	5.65	4.65	2.45	1.5	1.35
13	.85	1.85	5.5	4.65	2.4	1.5	1.45
14	1.05	2.0	5.6	4.6	2.45	1.5	1.35
15	1.25	2.05	5.8	4.65	2.55	1.4	1.4
16	1.4	2.25	6.2	4.2	2.55	1.4	1.5
17	1.55	2.45	6.8	4.1	2.45	1.4	1.35
18	1.4	2.75	7.25	4.05	2.55	1.4	1.3
19	1.3	3.15	7.15	3.95	2.7	1.5	1.2
20	1.3	3.5	7.3	3.75	2.7	1.4	1.2
21	1.4	4.9	7.55	4.4	2.55	1.4	1.1
22	1.5	6.8	7.8	3.85	2.35	1.3	1.1
23	1.4	7.25	7.85	3.75	2.2	1.3	1.1
24	1.3	7.2	7.75	3.75	2.2	1.3	1.1
25	1.2	7.05	6.8	4.1	2.1	1.2	1.0
26	1.3	7.0	5.85	4.05	2.05	1.2	1.0
27	1.4	5.6	5.7	3.85	1.85	1.2	.9
28	1.45	5.15	5.85	3.4	2.05	1.2	.9
29	1.55	4.7	5.4	3.1	2.25	1.2	.9
30	1.65	4.55	4.6	3.0	2.5	1.1	.8
31	.....	4.75	.....	3.05	2.7	.....	.8

Rating table for Bighorn River near Thermopolis, Wyo., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.20	150	1.60	1,530	3.00	3,820	4.80	7,530
.30	210	1.70	1,660	3.10	4,020	5.00	7,950
.40	280	1.80	1,800	3.20	4,220	5.20	8,380
.50	350	1.90	1,940	3.30	4,420	5.40	8,810
.60	430	2.00	2,080	3.40	4,620	5.60	9,240
.70	520	2.10	2,230	3.50	4,820	5.80	9,670
.80	620	2.20	2,390	3.60	5,020	6.00	10,100
.90	720	2.30	2,550	3.70	5,220	6.20	10,530
1.00	820	2.40	2,720	3.80	5,430	6.40	10,960
1.10	930	2.50	2,890	3.90	5,640	6.60	11,390
1.20	1,040	2.60	3,070	4.00	5,850	6.80	11,820
1.30	1,160	2.70	3,250	4.20	6,270	7.00	12,250
1.40	1,280	2.80	3,440	4.40	6,690	7.50	13,350
1.50	1,400	2.90	3,630	4.60	7,110	8.00	14,500

The above table is applicable only for open-channel conditions. It is based upon 10 discharge measurements made during 1904. It is well defined.

Estimated monthly discharge of Bighorn River near Thermopolis, Wyo., for 1904.

[Drainage area, 8,184 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	1,595	180	873	51,950	0.107	0.119
May	12,800	1,400	4,984	306,500	.609	.702
June	14,160	6,795	10,370	617,100	1.27	1.42
July	9,347	3,820	6,551	402,800	.800	.922
August	3,920	1,870	2,946	181,100	.360	.415
September	2,805	930	1,470	87,470	.180	.201
October	1,400	620	974	59,890	.119	.137
The period				1,707,000		

BIGHORN RIVER AT FORT CUSTER, MONT.

This station was established June 16, 1904, by R. S. Stockton. It is located at the bridge of the Burlington and Missouri Railroad, about one-half mile above the junction of the Bighorn and Little Bighorn rivers. The nearest post-office is at Crow Agency, Mont., 11 miles distant; and the nearest town is Billings, Mont., 60 miles distant. A standard chain gage is fastened near the middle of the first span from the east bank. The length of the chain from the end of the weight to the marker is 31.71 feet. The gage is read twice each day by O. D. Hogue. Discharge measurements are made from the upper side of the three-span bridge to which the gage is attached. The initial point for soundings is at the east abutment of the bridge. Each 10-foot point is marked upon the bridge timbers. The channel is straight for about 400 feet above and 300 feet below the station, and the current is swift. The right bank is high, and can not be overflowed. The left bank is low, and is subject to overflow in extreme high water. The bed of the stream is composed of gravel, and is free from vegetation. There is but one channel at all ordinary stages, broken by two piers. Bench mark No. 1 is on the top of the east concrete abutment at the south end, on mark XXXIII. Its elevation is 14.90 feet above the zero of the gage. Bench mark No. 2 is on the top of first concrete pier west of the east abutment on the south end of the pier, on mark XXXVI. Its elevation is 14.85 feet above the zero of the gage. Bench mark No. 3 is on the top of the south end of the west concrete abutment, on mark XXXIV. Its elevation is 14.88 feet above the zero of the gage. The gage zero is approximately 2,879.10 feet above sea level.

The observations at this station since its establishment were made under the direction of C. C. Babb, district engineer.

Discharge measurements of Bighorn River at Fort Custer, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 16	R. S. Stockton	438	2,655	3.91	9.00	10,379
July 27	do	438	2,357	3.76	8.30	8,867
September 17	W. B. Freeman	427	1,376	1.50	6.00	2,069
October 1	R. S. Stockton	426	1,295	1.25	5.69	1,615
October 24	L. R. Stockman	418	1,310	1.28	5.65	1,673

Mean daily gage height, in feet, of Bighorn River at Fort Custer, Mont., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	9.47	7.82	6.70	5.70	5.70	5.65
2	.....	9.47	7.70	6.60	5.70	5.70	5.65
3	.....	9.35	7.58	6.52	5.70	5.70	5.65
4	.....	9.75	7.45	6.50	5.65	5.70	5.65
5	.....	9.45	7.38	6.48	5.65	5.60	5.65
6	.....	9.40	7.28	6.40	5.65	5.60	5.70
7	.....	9.30	7.15	6.40	5.65	5.60	5.70
8	.....	9.45	7.13	6.38	5.65	5.60	5.70
9	.....	9.35	7.03	6.30	5.65	5.60	5.70
10	.....	9.22	6.97	6.22	5.65	5.60	5.70
11	.....	9.10	6.95	6.10	5.65	5.50	5.70
12	.....	9.40	6.87	6.08	5.65	5.50	5.70
13	.....	9.37	6.83	6.00	5.70	5.50	5.70
14	.....	9.25	6.80	5.92	5.75	5.50	5.70
15	.....	9.07	6.85	6.02	5.75	5.50	5.70
16	10.05	8.92	6.83	6.00	5.80	5.50	5.70
17	10.10	8.90	6.75	6.00	5.80	5.50	5.70
18	10.37	8.70	6.75	6.00	5.80	5.60	5.70
19	10.35	8.50	6.75	5.95	5.80	5.60	5.70
20	10.55	8.40	6.13	5.92	5.80	5.65	5.70
21	10.62	8.25	7.05	5.90	5.75	5.65	5.70
22	10.57	8.05	6.97	5.90	5.75	5.65	5.70
23	10.65	8.45	6.95	5.85	5.75	5.65	5.70
24	10.69	8.65	6.80	5.80	5.70	5.65	5.70
25	10.30	8.40	6.60	5.75	5.80	5.65	5.70
26	10.10	7.95	6.55	5.75	5.75	5.65	5.70
27	9.70	8.15	6.45	5.75	5.75	5.65	5.70
28	9.40	8.25	6.40	5.70	5.75	5.65	5.70
29	9.20	8.20	6.40	5.70	5.70	5.65	5.70
30	9.25	8.10	6.57	5.70	5.70	5.65	5.70
31	.....	8.02	6.47	.....	5.70	.....	5.70

SHOSHONE RIVER NEAR CODY, WYO.

This station was established April 26, 1902, by A. J. Parshall. It is located at the wagon bridge 1 mile northwest of Cody, Wyo. The gage is a plain staff graduated to half tenths and is fastened to the bridge from which discharge measurements are made. The initial point for soundings is on the left bank. The channel is straight both above and below the station. The current is swift. The right bank is low and subject to overflow. The left bank is high and does not overflow. The bed of the stream is gravel and rock. The bench mark is a bolt in the bridge sleeper 1.15 feet above the 12-foot mark on the gage. It is indicated by a cross. The observer, W. J. Kissick, reads the gage twice daily.

The observations at this station during 1904 have been made under the direction of A. J. Parshall, resident hydrographer.

Discharge measurements of Shoshone River near Cody, Wyo., 1902–1904.

Date.	Hydrographer.	Width.	Area of sections.	Mean velocity.	Gage height.	Discharge.
1902.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 26	A. J. Parshall		279	1.92	2.40	538
June 7	do		658	6.61	4.80	4,352
July 17	do		579	4.86	4.10	2,812
July 31	do		527	3.87	3.65	2,039
December 8	do		231	1.32	2.00	270
1903.						
March 20	A. J. Parshall		219	1.10	1.95	263
April 21	do		318	1.95	2.41	633
April 25	do		427	3.18	3.00	1,399
May 19	do		405	3.09	3.20	1,374
May 20	do		421	2.89	3.00	1,263
June 6	J. Ahern		698	3.76	4.70	2,624
June 11	do		865	6.35	5.25	5,502
June 16	A. J. Parshall		903	8.20	5.70	7,297
June 17	do		1,113	8.15	6.10	8,885
June 18	do		993	9.89	6.20	8,840
June 24	do		665	6.34	5.10	4,212
July 14	do		680	5.53	4.70	3,829
July 15	do		630	5.24	4.50	3,299
July 25	do				4.25	3,087
October 31	J. Ahern		337	1.33	2.20	450
1904.						
March 29	A. J. Parshall	97	238	1.06	1.90	253
April 30	W. E. Young	148	564	2.72	3.40	1,536
May 22	J. Ahern	178	786	7.89	5.50	6,200
June 17	do	196	880	7.19	6.10	6,330
June 20	do	206	1,122	8.12	6.45	9,116
August 27	do	128	413	2.87	3.15	1,186
September 9	A. J. Parshall	128	376	2.35	2.78	885
October 8	J. Ahern	110	268	1.54	2.20	413
December 22	do		249	1.29	1.90	321

Mean daily gage height, in feet, of Shoshone River near Cody, Wyo., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.0	2.2	2.0	3.5	5.65	5.9	4.0	3.0	2.2	2.0	1.5
2	1.9	1.9	2.1	2.0	3.3	4.9	5.9	4.0	3.0	2.0	2.0	1.5
3	2.0	1.9	2.0	2.0	3.8	4.9	5.8	4.0	2.9	1.9	1.9	1.6
4	1.5	2.0	2.2	2.1	3.8	4.95	5.7	3.9	2.9	1.8	1.9	1.6
5	1.4	2.0	2.1	2.1	3.7	4.95	5.8	3.8	3.0	1.9	1.9	1.5
6	1.3	1.9	2.0	2.0	3.8	4.9	5.7	3.8	2.9	1.8	1.8	1.5
7	1.4	1.9	2.1	2.2	3.7	4.9	5.7	3.8	3.0	1.7	1.8	1.5
8	1.2	2.0	2.1	2.1	3.7	5.0	5.9	3.9	3.0	1.9	1.7	1.5
9	1.4	2.0	2.2	2.0	3.9	5.2	6.0	3.9	2.9	2.0	1.8	1.4
10	1.5	1.9	2.1	2.2	3.8	5.8	6.0	3.8	2.8	1.8	1.7	1.4
11	1.5	1.9	2.1	3.0	3.8	5.25	5.9	4.0	2.8	1.8	1.7	1.4
12	2.0	2.0	2.0	3.1	3.9	5.5	5.8	3.9	2.7	1.8	1.8	1.4
13	1.7	1.9	2.2	3.2	4.0	5.7	6.0	3.9	2.6	1.9	1.8	1.4
14	1.8	2.0	2.1	4.0	3.9	5.8	6.0	3.8	2.6	1.9	1.8	1.3
15	1.5	2.1	2.0	3.9	4.1	5.8	5.9	3.7	2.6	1.7	1.8	1.3
16	1.4	2.0	2.0	3.5	4.0	5.8	5.9	3.8	2.5	1.7	1.7	1.3
17	1.3	2.0	2.1	3.0	4.0	5.8	5.9	3.8	2.5	1.8	1.8	1.2
18	1.9	1.9	2.0	3.0	4.2	6.9	6.0	3.9	2.5	1.8	1.8	1.1
19	2.0	2.0	2.0	3.0	5.0	7.0	5.9	4.0	2.5	1.7	1.9	1.0
20	1.7	2.0	2.0	2.9	5.2	7.0	5.8	3.9	2.4	1.7	1.9	1.0
21	1.8	1.9	2.1	3.0	5.5	6.85	5.7	3.8	2.4	1.8	1.8	1.0
22	1.6	2.0	2.1	3.1	5.5	6.8	5.5	3.7	2.4	1.8	1.7	1.0
23	1.7	2.1	2.0	3.0	6.0	6.3	5.0	3.7	2.3	1.8	1.7	.9
24	1.9	2.1	2.1	2.9	6.0	6.0	4.9	3.8	2.4	1.9	1.7	.9
25	2.0	2.1	2.1	3.0	5.8	5.3	4.8	3.7	2.4	1.9	1.7	.9
26	1.9	2.2	2.0	3.9	5.1	5.25	4.8	3.5	2.3	1.9	1.6	.9
27	1.8	2.2	2.1	4.0	5.0	5.4	4.7	3.0	2.2	1.8	1.6	.9
28	1.9	2.2	2.1	3.9	5.1	5.35	4.7	3.0	2.2	1.8	1.6	.8
29	2.0	2.0	2.0	3.8	5.1	5.35	4.5	3.0	2.1	2.0	1.6	.8
30	2.0	.....	2.1	3.7	5.0	5.55	4.3	3.0	2.0	1.9	1.5	.9
31	2.0	.....	2.2	.....	5.3	.....	4.0	3.0	.....	1.9	.....	1.0

Rating table for Shoshone River near Cody, Wyo., from April 26, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.80	200	2.90	1,020	4.00	2,440	5.20	5,370
1.90	245	3.00	1,120	4.10	2,610	5.40	6,070
2.00	295	3.10	1,225	4.20	2,800	5.60	6,810
2.10	355	3.20	1,335	4.30	3,000	5.80	7,550
2.20	425	3.30	1,450	4.40	3,210	6.00	8,290
2.30	500	3.40	1,575	4.50	3,420	6.20	9,030
2.40	575	3.50	1,710	4.60	3,650	6.40	9,770
2.50	655	3.60	1,850	4.70	3,900	6.60	10,510
2.60	740	3.70	1,990	4.80	4,170	6.80	11,250
2.70	830	3.80	2,130	4.90	4,440	7.00	11,990
2.80	925	3.90	2,280	5.00	4,730		

The preceding table is applicable only for open-channel conditions. It is based upon 28 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 1.9 feet and 6.2 feet. The table has been extended beyond these limits, and is only approximate below gage height 1.90 feet. Above gage height 5.4 feet the rating curve is a tangent, the difference being 370 per tenth.

NOTE.—The preceding table supersedes the 1903 table below gage height 2 feet and is the same as the 1903 table above gage height 2 feet.

Estimated monthly discharge of Shoshone River near Cody, Wyo., 1902–1904, superseding monthly estimates previously published.

[Drainage area, 1,480 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
May	7,365	655	2,698	165,900	1.82	2.10
June	10,510	3,420	5,654	336,400	3.82	4.26
July	3,775	2,440	2,779	170,900	1.88	2.17
August	2,440	655	1,343	82,580	.907	1.05
September	655	655	655	38,980	.443	.494
October	655	655	655	40,270	.443	.510
The period				835,000		
1903.						
January	390	270	303	18,630	.205	.236
February	295	245	283	15,720	.191	.199
March	925	223	333	20,480	.225	.259
April	2,360	295	847	50,400	.572	.638
May	2,900	878	1,558	95,800	1.05	1.21
June	10,140	3,420	6,819	405,800	4.61	5.14
July	6,070	2,060	3,562	219,000	2.41	2.78
August	2,280	575	1,566	96,290	1.06	1.22
September	355	98	235	13,980	.159	.177
October	1,070	295	577	35,480	.390	.450
November	878	270	499	29,690	.337	.376
December	830	120	441	27,120	.298	.344
The year	10,140	98	1,419	1,028,000	.959	13.03
1904.						
January	295	80	192	11,810	.130	.150
February	425	245	301	17,310	.203	.219
March	425	295	345	21,210	.233	.269
April	2,440	295	1,154	68,670	.780	.870
May	8,290	1,450	3,766	231,600	2.54	2.93
June	11,990	4,440	7,087	421,700	4.79	5.34
July	8,290	2,440	6,592	405,300	4.45	5.13
August	2,440	1,120	2,019	124,100	1.36	1.57

Estimated monthly discharge of Shoshone River near Cody, Wyo., 1902–1904, superseding monthly estimates previously published—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1904.						
September	1,120	295	752	44,750	0.508	0.567
October	425	165	225	13,830	.152	.175
November	295	120	194	11,540	.131	.146
December	140	40	85	5,226	.057	.066
The year	11,990	40	1,893	1,377,000	1.28	17.44

CLEAR CREEK AT BUFFALO, WYO.

This station was established October 24, 1902, by Jeremiah Ahern. It is located at the highway bridge in the town of Buffalo, Johnson County, Wyo. The gage is a plain staff graduated to feet and tenths, spiked to the pier at the northwest end of the bridge. The initial point for soundings is on the left bank. Measurements are made from the bridge. The channel is straight both above and below the station. Both banks are high and rocky. The bed of the stream is also rocky. The gage is read daily by P. A. Gatchell. The bench mark is U. S. G. S. B. M. at the court-house, marked "SHER 4635." Its elevation is 4,635.033 feet above sea level. The elevation of the gage as determined from this bench mark is 4,605.766 feet.

The observations at this station during 1904 have been made under the direction of A. J. Parshall, resident hydrographer.

Discharge measurements of Clear Creek at Buffalo, Wyo., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 9[a]	A. J. Parshall	37	71	2.96	1.80	210
May 10[a]	do	38	79	3.33	2.00	263
May 19[a]	do	39	82	3.29	2.00	270
May 20[a]	do	40	115	5.76	3.05	663
May 21[a]	do	40	96	4.71	2.50	452
May 22[a]	do	40	109	5.21	2.80	568
June 11[a]	do	40	109	5.18	2.80	565
June 12[a]	do	40	89	3.64	2.20	324
July 7[a]	do	37	66	2.11	1.65	139
July 17[a]	do	36	55	1.64	1.50	91
September 11[b]	do	16	14	.86	.70	12
October 14[a]	do	25	34	.74	.95	24

[a] Foot bridge 300 yards above station. [b] Wading one-third mile above foot bridge.

Mean daily gage height, in feet, of Clear Creek at Buffalo, Wyo., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	1.2	1.3	1.2	0.8	1.7	2.9	1.8	1.3	0.8	0.7	0.7	0.75
2	1.2	1.2	1.3	.8	1.9	2.65	2.75	1.3	.8	.7	.7	.75
3	1.3	1.2	1.4	.8	3.0	2.3	2.55	1.2	.8	.7	.7	.75
4	1.3	1.3	1.2	.8	2.5	2.0	2.0	1.2	.8	.7	.7	.75
5	1.4	1.2	1.2	.8	2.5	2.2	2.0	1.2	.8	.7	.7	.75
6	1.5	1.2	1.2	.8	2.3	2.3	2.0	1.2	.8	.75	.7	.75
7	1.6	1.2	1.1	.8	2.1	2.55	1.9	1.1	.75	.7	.7	.75
8	1.4	1.1	1.0	.8	2.0	3.15	1.8	1.0	.75	.7	.7	.75
9	1.3	1.0	1.0	.8	1.9	2.65	1.8	1.0	.75	.7	.7	.75
10	1.2	1.0	1.0	.8	1.9	2.50	1.8	.9	.75	.75	.7	.75
11	1.2	1.1	1.0	.8	1.9	3.0	1.8	.85	.75	.75	.7	.75
12	1.2	1.1	1.0	1.0	1.9	2.5	1.8	.8	.75	.8	.7	.75
13	1.1	1.1	1.0	1.3	1.9	2.35	1.8	.75	.75	.85	.7	.8
14	1.2	1.1	.9	1.2	1.9	2.55	1.75	.75	.75	.95	.7	.8
15	1.2	1.1	.8	1.1	1.9	2.65	1.7	.75	.7	.95	.7	.8
16	1.2	1.2	.7	1.0	2.0	2.85	1.6	.75	.7	.95	.7	.8
17	1.2	1.2	.7	1.0	2.0	2.7	1.6	.75	.7	.95	.7	.9
18	1.2	1.2	.7	1.1	2.0	2.6	1.5	.75	.7	.9	.75	.9
19	1.3	1.2	.7	1.2	2.1	2.5	1.45	1.0	.7	.9	.75	.9
20	1.4	1.2	.7	1.5	3.0	2.5	1.4	1.1	.7	.85	.75	.9
21	1.7	1.2	.8	1.4	2.7	2.5	1.4	.8	.7	.8	.75	1.0
22	1.6	1.3	.8	1.3	2.7	2.5	1.4	.8	.7	.8	.75	1.0
23	1.9	1.8	.8	1.4	2.8	2.5	1.4	1.5	.7	.8	.75	1.0
24	1.8	1.0	1.0	1.4	2.8	2.35	1.4	1.5	.7	.8	.75	1.0
25	1.7	.9	1.0	1.3	3.0	2.1	1.4	1.0	.7	.75	.75	1.0
26	1.6	2.0	.8	1.2	2.7	2.0	1.4	.9	.7	.75	.75	1.0
27	1.5	1.2	.8	1.3	2.7	1.8	1.4	.9	.7	.8	.75	1.0
28	1.4	1.2	.7	1.4	2.2	1.8	1.4	.9	.7	.8	.75	1.0
29	1.4	1.2	.8	1.6	2.2	1.8	1.4	.85	.7	.8	.75	1.0
30	1.3	.....	.8	1.6	2.4	1.8	1.35	.8	.7	.75	.75	1.0
31	1.3	.....	.8	.....	2.5	.....	1.3	.8	.....	.7	.....	1.0

[a] Creek frozen most of the time from January 1 to March 15 and December 1 to 31

Rating table for Clear Creek at Buffalo, Wyo., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.60	7	1.00	32	1.80	202	2.60	486
.65	9	1.10	42	1.90	234	2.70	526
.70	11	1.20	54	2.00	266	2.80	566
.75	14	1.30	70	2.10	302	2.90	606
.80	17	1.40	92	2.20	338	3.00	646
.85	20	1.50	116	2.30	374	3.10	686
.90	24	1.60	140	2.40	410	3.20	726
.95	28	1.70	170	2.50	446		

The above table is applicable only for open-channel conditions. It is based upon 12 discharge measurements made during 1904. It is not well defined.

Estimated monthly discharge of Clear Creek at Buffalo, Wyo., for 1904.

[Drainage area, 118 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 16–31	32	11	16.6	527	0.141	0.084
April	140	17	52.4	3,118	.444	.495
May	646	170	377	23,180	3.19	3.68
June	706	202	421	25,050	3.57	3.98
July	546	70	174	10,700	1.47	1.70
August	116	14	35.6	2,189	.302	.348
September	17	11	13.0	774	.110	.123
October	28	11	16.7	1,027	.142	.164
November	14	11	12.3	732	.104	.116
The period				67,300		

PINEY CREEK AT KEARNEY, WYO.

This station was established September 6, 1902, by Jeremiah Ahern. It is located at the highway bridge at Kearney, Johnson County, Wyo., which is on the stage route between Sheridan and Buffalo, 24 miles from Sheridan. The gage is a vertical staff graduated to feet and tenths and spiked to the abutment of the bridge. It is read daily by R. D. Noyce. The initial point for soundings is on the right bank. Discharge measurements are made from the bridge. The channel is straight for 600 feet above and 200 feet below the station. The left bank is high and liable to overflow at extreme high water. The right bank is high and does not overflow. The bed of the stream is composed of gravel. The bench mark is the U. S. G. S. bench mark at Geier's ranch, about 600 feet from the gage. It is marked "SHER 4662." Its elevation is 4,661.767 feet above sea level. The elevation of the zero of the gage as referred to this bench mark is 4,645.963 feet.

The observations at this station during 1904 have been made under the direction of A. J. Parshall, resident hydrographer.

Discharge measurements of Piney Creek at Kearney, Wyo., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 31	A. J. Parshall	42	0.95	1.50	40
May 9	do	106	2.82	2.55	299
May 20	do	149	5.03	3.10	749
May 21	do	134	4.62	2.95	620
June 12	do	125	4.24	2.85	530
July 8	do	92	1.42	2.05	131
July 18	do	84	1.03	1.85	87
September 12	do	49	0.45	1.30	22
October 12 [a]	do	18	1.83	1.40	33

[a] Wading one-fourth mile above station.

Mean daily gage height, in feet, of Piney Creek at Kearney, Wyo., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	1.5	1.45	1.5	1.6	2.35	3.08	2.1	1.5	1.2	1.18	1.5	.....
2	1.5	1.45	1.5	1.55	2.5	2.9	2.5	1.5	1.2	1.18	1.5	.....
3	1.5	1.45	1.5	1.55	3.13	2.82	2.5	1.45	1.2	1.18	1.35	.....
4	1.5	1.4	1.5	1.6	3.1	2.72	2.42	1.45	1.2	1.25	1.35	.....
5	1.5	1.4	1.5	1.6	3.0	2.85	2.32	1.4	1.2	1.25	1.35	.....
6	1.5	1.4	1.5	1.7	2.9	3.0	2.3	1.4	1.2	1.25	1.35	.....
7	1.5	1.4	1.5	1.8	2.85	3.0	2.27	1.4	1.2	1.25	1.35	.....
8	1.5	1.4	1.5	1.7	2.8	3.25	2.22	1.35	1.2	1.25	1.35	.....
9	1.5	1.4	1.45	1.7	2.7	2.98	2.12	1.3	1.2	1.25	1.35	.....
10	1.5	1.4	1.45	1.75	2.7	3.0	2.08	1.35	1.2	1.25	1.35	.....
11	1.5	1.4	1.45	1.8	2.65	3.18	2.02	1.4	1.2	1.25	1.35	.....
12	1.5	1.45	1.45	1.9	2.6	2.9	2.01	1.4	1.2	1.25	1.3	.....
13	1.5	1.45	1.45	1.9	2.55	2.8	2.08	1.4	1.2	1.4	1.3	.....
14	1.5	1.45	1.5	2.0	2.55	2.98	2.02	1.4	1.2	1.4	1.35	.....
15	1.5	1.45	1.5	2.0	2.6	3.1	1.95	1.4	1.25	1.35	1.35	.....
16	1.5	1.45	1.5	2.0	2.6	3.1	1.92	1.4	1.25	1.35	1.38	.....
17	1.5	1.45	1.5	2.05	2.65	3.08	1.9	1.4	1.25	1.4	1.38	.....
18	1.5	1.45	1.5	2.0	2.7	2.99	1.84	1.35	1.22	1.5	1.38	.....
19	1.5	1.45	1.5	2.0	2.8	3.02	1.72	1.35	1.22	1.5	1.38	.....
20	1.5	1.45	1.5	2.1	3.2	2.92	1.62	1.35	1.22	1.5	1.38	.....
21	1.45	1.45	1.5	2.15	2.9	2.85	1.58	1.4	1.2	1.5	1.35	.....
22	1.45	1.45	1.5	2.2	3.3	2.85	1.52	1.4	1.2	1.5	1.35	.....
23	1.45	1.5	1.5	2.2	3.45	2.70	1.5	1.3	1.2	1.5	1.35	.....
24	1.45	1.5	1.5	2.2	3.25	2.72	1.5	1.25	1.2	1.5	1.35	.....
25	1.45	1.5	1.5	2.25	3.2	2.42	1.68	1.2	1.2	1.5	1.35	.....
26	1.45	1.5	1.5	2.25	2.9	2.28	1.62	1.2	1.18	1.5	1.35	.....
27	1.45	1.5	1.5	2.25	2.8	2.08	1.58	1.2	1.18	1.5	1.35	.....
28	1.45	1.5	1.5	2.3	2.75	2.00	1.55	1.2	1.18	1.5	1.35	.....
29	1.45	1.5	1.55	2.3	2.85	2.04	1.51	1.2	1.18	1.5	1.35	.....
30	1.45	.....	1.6	2.35	3.0	2.10	1.5	1.2	1.18	1.5	1.35	.....
31	1.45	.....	1.6	.....	3.15	.....	1.5	1.2	.....	1.5	.....	.....

[a] Frozen greater portion of time, January 1 to March 15.
[b] Frozen during month.

Rating table for Piney Creek at Kearney, Wyo., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.15	12	1.50	38	2.20	178	2.90	580
1.20	15	1.60	48	2.30	218	3.00	660
1.25	18	1.70	60	2.40	262	3.10	750
1.30	21	1.80	76	2.50	310	3.20	850
1.35	25	1.90	96	2.60	364	3.30	960
1.40	29	2.00	118	2.70	430	3.40	1,080
1.45	33	2.10	144	2.80	500	3.50	1,200

The above table is applicable only for open-channel conditions. It is based upon 9 discharge measurements made during 1904. It is well defined between gage heights 1.3 feet and 3 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Piney Creek at Kearney, Wyo., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
March 16–31	48	38	39.6	1,257
April	240	43	122	7,260
May	1,140	240	566	34,800
June	905	118	534	31,780
July	310	38	117	7,194
August	38	15	25.2	1,550
September	18	14	15.2	904
October	38	14	28.2	1,734
November	38	21	25.9	1,541
The period				88,020

LITTLE MISSOURI RIVER NEAR ALZADA, MONT.

This station was established April 3, 1904, by F. M. Madden. It is located at the highway bridge on the old Spearfish and Miles City stage road, about one-half mile northwest of Alzada, Mont. A plain staff gage, graduated to feet and tenths, is attached vertically to the downstream side of the crib pier supporting the middle of the bridge. It is read once each day by Miss Elsie King. Discharge measurements are made at high stages from the downstream side of the two-span bridge to which the gage is attached. During low-water periods measurements are made by wading near the gage. The initial point for soundings is a bolt in the downstream hand rail near the left end

of the bridge. The channel is straight above and below the station for about 200 feet and the current is moderately swift. Both banks are high, but subject to overflow in extreme high water. The bed of the stream is composed of fine silt and is permanent. Below the section willows grow in some places so that the branches reach nearly across the channel. There is but one channel, broken by the middle crib pier of the bridge. The large rock-filled crib pier and ice breaker just above are the only obstructions in the channel at the station. Willows and brush on the banks tend to retard the flow during high water. Bench mark No. 1 is a spike driven into the base of a tree about 50 feet west of the left end of the bridge. Its elevation is 16.33 feet above the zero of the gage. Bench mark No. 2 is a United States Geological Survey standard bench mark in the town of Alzada, distant about 2,000 feet. Its elevation is 26.82 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Little Missouri River near Alzada, Mont., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 3	F. M. Madden	54	218	1.72	5.70	376
April 3	do	50	176	1.73	4.90	305
May 9	do	21	52	1.60	2.50	83
May 10	do	21	46	1.35	2.20	62
June 26	F. C. Magruder	18	29	.38	1.40	11
July 8 [a]	F. M. Madden	9	4.6	1.00	1.25	4.6
July 9 [a]	do	14	3.7	1.16	1.20	4.3
September 5 [b]	do	23	67	1.22	2.90	82

[a] At wading section.
[b] Flow lessened by large growth of willows during July and August.

Mean daily gage height, in feet, of Little Missouri River near Alzada, Mont., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	12.7	1.2	1.3	1.4	1.1	1.6	(a)	1.1
2	9.0	4.7	2.7	1.4	1.1	1.6	0.9	1.1
3	5.3	4.7	7.2	1.3	1.1	4.8	1.0	1.1
4	5.0	2.3	17.0	1.3	1.1	8.6	1.0	1.1
5	5.2	1.7	17.0	1.3	1.0	3.4	1.1	1.1
6	5.3	1.5	17.0	1.3	1.0	1.8	1.1	1.1
7	3.5	1.7	16.0	1.3	.9	1.7	1.1	1.1
8	2.75	1.4	5.3	1.3	.9	1.5	1.1	1.1
9	2.2	2.5	5.0	1.7	.9	1.3	1.1	1.1
10	2.0	2.2	5.1	1.8	.9	1.2	1.1	1.1
11	1.7	1.7	4.8	1.8	.9	1.2	1.1	1.1
12	1.5	1.5	3.0	1.5	.9	1.2	1.1	1.1
13	1.6	1.3	2.8	1.3	.9	1.2	1.1	1.1
14	1.65	1.3	2.2	1.3	.9	1.1	1.1	1.1
15	1.6	1.3	2.0	1.1	.9	1.05	1.1	1.1
16	1.5	1.3	1.9	1.1	.9	1.0	2.1	1.1
17	1.45	1.2	1.8	1.15	.9	.9	2.1	1.1
18	1.3	1.2	1.7	1.15	.9	.9	1.5	1.1
19	1.2	1.2	1.7	1.15	.9	.9	1.4	1.1
20	1.2	1.2	1.7	1.15	.9	.9	1.2	1.1
21	1.2	1.2	1.7	1.15	.9	.8	1.1	1.1
22	1.2	2.0	1.7	1.1	.9	(a)	1.1	1.1
23	1.2	1.5	1.7	1.1	.9	(a)	1.1	1.1
24	1.2	4.5	1.7	1.1	.9	(a)	1.1	1.1
25	1.2	2.3	1.5	1.1	.9	(a)	1.1	1.1
26	1.2	3.0	1.5	1.1	.9	(a)	1.1	1.1
27	1.2	2.5	1.5	1.1	.9	(a)	1.1	1.1
28	1.2	1.7	1.4	1.1	.9	(a)	1.1	1.1
29	1.2	1.5	1.6	1.1	.9	(a)	1.1	1.1
30	1.2	1.4	1.4	1.1	1.9	(a)	1.1	1.1
31	.....	1.3	.....	1.1	1.9	.....	1.1	.....

a River dry.

Rating table for Little Missouri River near Alzada, Mont., from April 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.00	1	2.30	69	3.60	178	4.90	300
1.10	2	2.40	77	3.70	187	5.00	310
1.20	4	2.50	85	3.80	196	5.10	320
1.30	7	2.60	93	3.90	205	5.20	330
1.40	11	2.70	101	4.00	214	5.30	340
1.50	15	2.80	109	4.10	223	5.40	350
1.60	20	2.90	117	4.20	232	5.50	360
1.70	25	3.00	125	4.30	241	5.60	370
1.80	31	3.10	133	4.40	250	5.70	380
1.90	38	3.20	142	4.50	260	5.80	390
2.00	45	3.30	151	4.60	270	5.90	400
2.10	53	3.40	160	4.70	280	6.00	411
2.20	61	3.50	169	4.80	290		

The preceding table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 1 foot and 6 feet. Discharges above gage height 6 feet are approximate estimates only. After August 29 reduce discharges as given by the table 30 per cent on account of back water effect of willows in channel below the gage. The flow is estimated as 0 second-feet at gage height .9 feet.

Estimated monthly discharge of Little Missouri River near Alzada, Mont., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
April	1,185	4	127	7,557
May	280	4	51.6	3,173
June	1,744	7	314	18,680
July	31	2	7.1	437
August [a]	27	0	2.0	123
September [a]	488	0	30.0	1,785
October [a]	37	0	4.1	252
November [a]	1.4	1.4	1.4	83
The period				32,090

[a] Estimates August 30 to November 30 approximate. See paragraph under rating table.

LITTLE MISSOURI RIVER NEAR CAMP CROOK, S. DAK.

This station was established September 2, 1903, by R. F. Walter, assisted by W. T. Carpenter. The station is at the highway bridge on the road from Camp Crook to Belle Fourche, about one-half mile from Camp Crook. The gage is a vertical 2 by 4 inch pine timber fastened to the first pier from the west end of the bridge, on the downstream side. It is graduated to feet and tenths with bronze figures marking the foot marks. The bridge at this station was destroyed March 9, 1904, by an ice jam which carried away the superstructure and nearly all of the two center piers, to one of which the gage was spiked. Records were kept by referring the height of the water to a temporary mark until the gage was reestablished April 10, by spiking a 2 by 4 inch pine gage to the east abutment and continuing the gage for low water on a 2 by 2 inch pine strip spiked to the remains of the pier near the east bank. The gage was read once each day by L. P. Chuning. Readings were discontinued November 13, as the gage was removed in preparing foundations for a new bridge. Discharge measurements were made from the bridge until it was destroyed, since which time they have been made by wading and by means of a boat or floats during extreme high water. The initial point for soundings was a brass-headed tack surrounded by four similar tacks driven into the end post of the hand rail at the west end

and downstream side of the bridge. The channel is straight for 300 feet above and 200 feet below the station. The current has a moderate velocity. The right bank is high and not subject to overflow. The left bank is subject to overflow at high water. Both banks are sparsely wooded. The bed of the stream is covered with stones, the largest of which are about 1 foot in diameter. The water flows in one channel at medium and high stages. Bench mark No. 1 is a large spike driven into a blaze on a tree 6 inches above the ground. The tree is at the side of the road, 100 feet from the end of the bridge, on the right bank. The elevation of the bench mark above the zero of the gage is 10.53 feet. Bench mark No. 2 is a large spike driven into a blaze on a tree about 6 inches above ground. The tree is on the opposite side of the road from the first bench mark and is 175 feet farther downstream. The elevation of the bench mark above the zero of the gage is 12.89 feet.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Little Missouri River near Camp Crook, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 10	F. M. Madden	100	124	2.11	1.60	262
May 10	do	61	47	1.15	.80	54
July 7	do	56	49	1.26	.85	62
September 6	do	108	214	2.84	2.60	609
September 7	do	100	141	2.28	1.90	321
September 7	do	100	131	2.21	1.80	289
September 7	do	98	116	2.03	1.55	235
October 26	do	40	19	.68	.45	13

Mean daily gage height, in feet, of Little Missouri River near Camp Crook, S. Dak., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	6.0	0.65	1.0	0.6	(b)	2.25	(b)	(b)
2	.....	5.7	.7	.9	.8	(b)	2.0	(b)	(b)
3	.....	5.5	.7	1.0	.9	(b)	1.5	(b)	(b)
4	.....	5.2	1.0	3.5	.9	(b)	1.3	(b)	(b)
5	2.8	4.0	1.8	8.0	.9	(b)	2.1	(b)	(b)
6	2.7	4.2	1.1	(a)	.7	(b)	2.65	(b)	(b)
7	2.6	3.5	1.0	(a)	.85	(b)	1.7	(b)	(b)
8	2.68	2.0	.9	6.4	.75	(b)	1.2	(b)	(b)
9	2.7	1.5	.85	4.0	.75	(b)	1.3	(b)	(b)
10	6.0	1.6	.8	3.2	.7	(b)	1.3	(b)	(b)
11	5.32	1.35	.8	2.9	.7	(b)	1.2	(b)	(b)
12	5.0	1.2	.8	2.7	.6	(b)	1.0	(b)	(b)
13	5.7	1.0	.8	2.3	.75	(b)	.8	(b)	(c)
14	4.25	.9	.8	1.8	.8	(b)	.55	0.3	.....
15	4.22	.9	.8	1.6	.7	(b)	.5	.2	.....
16	4.8	1.0	.8	1.5	.7	(b)	.5	(b)	.....
17	4.6	.9	.75	1.4	.7	(b)	.55	(b)	.....
18	4.7	.9	.75	1.1	.7	(b)	.55	(b)	.....
19	4.8	.8	.75	1.0	.7	(b)	.5	(b)	.....
20	4.7	.8	.75	.9	.7	(b)	.4	(b)	.....
21	4.6	.8	.7	.8	.65	(b)	.4	(b)	.....
22	4.4	.7	.55	.7	.5	(b)	.35	(b)	.....
23	4.3	.7	.55	.8	.5	(b)	.3	(b)	.....
24	4.3	.7	.6	.9	.5	(b)	.3	(b)	.....
25	4.3	.7	.6	1.0	.5	(b)	.2	(b)	.....
26	4.2	.7	3.9	1.0	.45	(b)	.2	(b)	.....
27	4.2	.7	3.3	.9	.45	(b)	.1	(b)	.....
28	4.6	.65	2.95	.8	.45	(b)	.1	(b)	.....
29	4.6	.65	1.5	.7	.4	(b)	.1	(b)	.....
30	5.0	.65	1.3	.6	.4	(b)	(b)	(b)	.....
31	5.5	.....	1.0	.....	(b)	(b)	.....	(b)	.....

a Water over gage.
b Water below gage.
c Station was closed on November 13, as gage was removed to construct new bridge.

Rating table for Little Missouri River near Camp Crook, S. Dak., from March 5 to November 13, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.10	1	0.90	71	1.70	270	2.40	522
.20	3	1.00	90	1.80	302	2.50	563
.30	6	1.10	110	1.90	335	2.60	605
.40	11	1.20	132	2.00	370	2.70	648
.50	18	1.30	156	2.10	406	2.80	691
.60	28	1.40	182	2.20	443	2.90	735
.70	40	1.50	210	2.30	482	3.00	779
.80	54	1.60	239				

The preceding table is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 0.40 foot and 2.60 feet. Discharges above gage height 3 feet are estimated on the basis of the extension of the discharge curve. Estimates below 0.40 foot gage height are uncertain.

Estimated monthly discharge of Little Missouri River near Camp Crook, S. Dak., for 1904.

[Drainage area, 1,900 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 5–31	2,185	605	1,407	75,350	0.741	0.744
April	2,185	34	454	27,020	.239	.267
May	1,189	23	157	9,654	.083	.096
June, 28 days [a]	3,180	28	419	23,270	.221	.230
July [b]	71	0	35.8	2,201	.019	.022
August [b]						
September [b]	626	0	113	6,724	.059	.066
October [b]	6	0	0.29	18	.0002	.0002
The period				144,200		

[a] Water over gage June 6 and 7. No estimate made.
[b] Water below gage; July 31 to August 31, September 30 to October 13, and October 16 to November 13; estimated zero flow.

LITTLE MISSOURI RIVER NEAR MEDORA, N. DAK.

This station was established May 12, 1903, by F. E. Weymouth. It is located at the Northern Pacific Railway bridge, one-third mile west of the railroad station at Medora, N. Dak. A standard chain gage is located on the lower side of the railroad bridge at a point 91 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 30.75 feet. The stream cross section having been changed by the railroad a new chain and weight length of 31.12 feet was established on June 29, 1904, which made the reading agree with the timber gage. There is also a 1 by 6 inch vertical board gage, reading from 1 to 9 feet, nailed to a pile in the river about 200 feet above the bridge. The gage is read once each day by W. A. Brubaker. Discharge measurements are made from the railroad bridge to which the gage is attached. The initial point for soundings is the left end of the guard rail on the lower side of the bridge. This point is 2.9 feet west of the east face of the concrete abutment. The guard rail is marked and numbered every 10 feet with white paint. The channel is straight for 100 feet above the station and for 300 feet below. The right bank is low and overflows at very high stages. The left bank is almost perpendicular and has a height of 30 feet above

gage datum. There is but one channel, broken by one to three piers, according to the stage of the river. The bed of the stream is of clay and sand and sometimes scours from 5 to 8 feet during floods. At ordinary stages the bed of the stream changes only slightly. About November 1, 1903, the cross section at the bridge was temporarily changed by the railroad company during repairs to the bridge, continuing several months. The bench mark is the top of the southwest corner of the concrete abutment on the left bank. Its elevation above gage datum is 30.11 feet. The top of the gage pulley is 31.05 feet above gage datum. The gage datum is about 2,230 feet above sea level, as determined by hand level from the railroad station at Medora, N. Dak.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Little Missouri River near Medora, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 12	E. F. Chandler	136	475	3.04	5.91	1,444
June 29	R. Richards	69	149	1.59	4.16	236
June 30	do	68	143	1.54	4.04	221
August 3	do	30	76	.25	3.21	19
August 4 [a]	do	25	12	.91	3.20	11
September 7 [a]	E. F. Chandler	28	73	.37	3.30	27
October 27 [a]	L. L. Wilcox	18	9	2.36	3.23	21.5

[a] Measurement made by wading.

Mean daily gage height, in feet, of Little Missouri River near Medora, N. Dak., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.6	3.0	.....	6.5	4.2	3.7	4.2	3.2	3.3	2.8	3.2	.....
2	.....	.....	.....	7.0	4.0	4.8	4.2	3.2	3.4	2.8	3.2	.....
3	.....	.....	.....	6.5	4.0	5.6	4.0	3.2	3.3	2.8	3.3	.....
4	.....	.....	.....	6.3	3.9	6.0	4.0	3.1	3.3	2.7	3.2	.....
5	.....	.....	.....	6.2	3.9	5.5	3.8	3.1	3.4	2.7	3.2	.....
6	.....	.....	.....	6.2	4.2	7.25	4.3	3.0	3.3	2.7	3.2	.....
7	.....	.....	.....	6.8	4.4	7.15	4.4	2.8	3.9	2.7	3.1	.....
8	.....	.....	.....	6.7	4.3	10.75	4.0	2.8	4.3	2.7	3.1	.....
9	.....	.....	.....	5.8	4.0	10.75	3.9	2.9	4.2	2.5	3.1	.....
10	3.4	.....	4.8	5.9	4.0	8.75	3.8	3.0	4.0	2.4	3.1	.....
11	.....	.....	.....	4.5	3.8	7.9	3.6	3.2	4.0	3.5	3.1	.....
12	.....	.....	.....	4.5	3.8	6.25	3.4	3.1	3.8	3.6	3.1	.....
13	.....	.....	5.0	4.3	3.8	5.55	3.4	3.0	3.8	3.6	3.2	.....
14	.....	.....	5.6	4.3	3.8	4.85	3.4	3.0	3.8	3.5	3.2	.....
15	.....	.....	5.0	4.3	4.0	4.2	3.4	3.1	3.8	3.5	3.2	.....
16	.....	.....	5.7	4.3	4.0	4.0	3.4	3.1	3.7	3.5	3.2	.....
17	.....	.....	5.0	4.0	3.9	4.0	3.4	3.0	3.6	3.4	3.2	.....

[a] River frozen from January 1 to March 12. Gage heights to under surface of ice.

Mean daily gage height, in feet, of Little Missouri River near Medora, N. Dak., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
18	.....	.....	5.8	4.0	3.8	4.0	3.5	3.0	3.6	3.4	3.2	.....
19	.....	.....	5.3	3.8	3.8	3.9	3.5	2.9	3.6	3.5	3.2	.....
20	3.0	3.0	5.0	4.8	3.8	3.9	3.4	3.1	3.4	3.6	3.2	.....
21	.....	.....	5.0	4.6	3.8	3.7	3.4	3.2	3.4	3.5	3.2	.....
22	.....	.....	4.8	4.0	3.8	3.8	3.4	3.2	3.2	3.5	3.2	.....
23	.....	.....	6.0	3.8	3.8	4.1	3.3	3.1	3.1	3.4	3.2	.....
24	.....	.....	5.9	3.8	3.6	4.0	3.3	3.0	3.2	3.4	3.2	.....
25	.....	.....	5.9	3.8	4.2	4.0	3.3	3.0	3.1	3.3	3.2	.....
26	.....	.....	4.6	3.5	4.5	3.8	3.5	3.1	3.1	3.2	3.2	.....
27	.....	.....	4.6	3.5	3.9	3.8	3.5	3.1	3.0	3.2	(*a*)	.....
28	.....	.....	4.6	3.5	3.7	3.8	3.4	3.2	3.0	3.2	.....	.....
29	.....	4.3	4.6	4.0	3.7	4.1	3.4	3.2	2.8	3.2	.....	.....
30	3.0	.....	5.8	4.4	3.7	4.2	3.4	3.2	2.8	3.0	.....	.....
31	.....	.....	7.0	.....	3.7	.....	3.3	3.2	.....	3.2	.....	.....

a River frozen from November 27 to December 31, inclusive.

Rating table for Little Missouri River near Medora, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.20	15	4.00	195	4.70	507	5.40	992
3.30	27	4.10	229	4.80	566	5.50	1,076
3.40	44	4.20	266	4.90	628	5.60	1,163
3.50	64	4.30	307	5.00	694	5.70	1,252
3.60	86	4.40	352	5.10	763	5.80	1,343
3.70	110	4.50	400	5.20	836	5.90	1,436
3.80	136	4.60	452	5.30	912	6.00	1,530
3.90	164						

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1904. It is fairly defined between gage heights 3.2 feet and 6 feet. The daily discharges for gage heights beyond these limits have been estimated.

Estimated monthly discharge of Little Missouri River near Medora, N. Dak., for 1904.

[Drainage area, 6,625 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. Sq. mile.	Depth in inches.
March 13–31	2,480	452	986	37,160	0.149	0.105
April	2,480	64	797	47,420	.120	.134
May	352	86	180	11,070	.027	.031
June	6,042	110	1,193	70,990	.180	.201
July	352	27	103	6,333	.016	.018
August	15	4	10.1	621	.0015	.0017
September	307	4	80.3	4,778	.012	.013
October	86	2	33.1	2,035	.0050	.0058
November 1–26	27	10	13.7	706	.0021	.0020
The period				181,100		

KNIFE RIVER AT BRONCHO, N. DAK.

This station was established May 29, 1903, by F. E. Weymouth. It is located about 600 feet east of H. M. Haven's ranch house, where the post-office is located. The station is about 23 miles north of Hebron, N. Dak., which is on the Northern Pacific Railway. The standard chain gage is located on the right bank, with the pulley fastened to a 2 by 4 inch timber projecting horizontally. The length of the chain from the end of the weight to the leather marker is 29.89 feet. The horizontal scale is marked with white paint and reads from zero to 16 feet. The elevation of the center of pulley above gage zero is 18 feet. Two bench marks were established October 23, 1904. Bench mark No. 1 is the top of the post holding shore end of horizontal gage rod; elevation 18.26 feet above gage zero. Bench mark No. 2 is cross cut in the top of a gray bowlder set flush with surface of the ground about 5 feet behind crest of bank and in line with horizontal gage rod; elevation 27.27 feet. A temporary 2 by 4 inch vertical board gage is spiked to a tree on the right bank above the ford, three-fourths of a mile below the ranch. It reads from zero to 19.3 feet. The gage is read once each day by Sarah J. Smith. Discharge measurements are made from a car and ½-inch cable with a span of 150 feet. The tag wire, consisting of barbed wire with zinc markers every 10 feet, is stretched about 5 feet east of the cable. The initial point for soundings is the post to which the right end of the tag wire is fastened. The channel is straight for 100 feet above the station and for 200 feet below. The current velocity is moderate. Both banks are high, with a few small trees and some brush. The bed of the stream is composed of sand and gravel and is probably fairly permanent. The bench mark for the temporary gage rod is a spike in the tree to which the gage is

fastened at an elevation of 19.25 feet above its zero. The gage zero is about 1,870 feet above sea level, as determined by carrying an aneroid barometer four times between this station and Hebron, N. Dak. The drainage area of Knife River at this station is 1,260 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Knife River at Broncho, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 9	E. F. Chandler	87	616	3.27	11.32	2,012
July 2[a]	R. Richards	16	23	.55	.86	13.5
August 6[a]	do	11	6.2	.47	.71	2.9
August 21[a]	E. F. Chandler	27	9	.62	.85	5.6
August 24[a]	do	26	7.4	.57	.80	4.2
October 29[a]	do	13	10	.53	.88	5.2

[a] Measurement by wading.

Mean daily gage height, in feet, of Knife River at Broncho, N. Dak., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.80	2.90	1.10	0.90	0.80	0.75	0.70	0.90
2	6.90	2.70	1.10	.85	.80	.75	.70	.90
3	10.20	2.40	1.10	.85	.80	.75	.70	.90
4	15.20	2.00	1.30	.85	.80	.70	.70	.90
5	18.40	2.00	1.30	.80	.80	.70	.70	.90
6	16.00	2.00	3.00	.80	.80	.70	.70	.90
7	14.40	1.80	2.40	.80	.80	.70	.70	.90
8	12.40	1.70	2.80	.80	.80	.70	.70	.90
9	11.40	1.60	1.70	.80	.80	.70	.70	.90
10	9.40	1.50	2.30	1.00	.80	.70	.70	.90
11	9.70	1.40	2.00	1.10	.75	.70	.70	.90
12	9.40	1.40	1.10	1.00	.75	.70	.75	.90
13	8.80	1.30	.70	1.00	.75	.70	.75	.90
14	6.70	1.30	.50	.95	.70	.70	.80	.90
15	5.40	1.30	1.30	.90	.70	.70	.80	.90
16	4.60	1.30	1.20	.85	.70	.70	.80	.90
17	3.70	1.30	1.20	.85	.70	.70	.80	.90
18	2.80	1.30	1.00	.80	.70	.70	.80	.90
19	2.20	1.30	1.00	.80	.75	.70	.80	.90
20	1.80	1.30	1.00	.80	.80	.70	.85	.90
21	1.80	1.25	1.00	.80	.80	.70	.85	.90
22	1.70	1.20	1.00	.80	.75	.70	.85	.90
23	1.60	1.15	1.00	.80	.75	.70	.85	.90
24	1.80	1.10	1.00	.80	.75	.70	.90	.90
25	2.00	1.10	1.00	.80	.75	.70	.90	.90
26	2.00	1.10	1.00	.80	.70	.70	.90	.90
27	2.00	1.10	1.00	.80	.70	.70	.90	.....
28	2.10	1.10	1.00	.80	.70	.70	.90	.....
29	2.20	1.10	1.00	.80	.70	.70	.90	.....
30	2.20	1.10	1.00	.80	.70	.70	.90	.....
31	.....	1.10	.....	.80	.70	.....	.90	.....

HEART RIVER NEAR RICHARDTON, N. DAK.

This station was established June 2, 1903, by F. E. Weymouth. It is located at the iron highway bridge 10 miles south of the Northern Pacific Railway station at Richardton, N. Dak. The standard chain gage is located on the lower side of the bridge. The scale, reading from 2 to 23 feet, is marked on the foot guard rail with wire staples and white paint marks. The length of the chain is 24.34 feet from the end of the weight to the marker. The gage is read once each day by W. F. Church. Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the end of the guard rail on the lower side of the bridge at the left bank. Distances are marked and numbered with white paint every 10 feet across the entire length of the bridge. The channel is straight for 150 feet above and below the station. The current velocity is moderate. Both banks are high and covered with brush. The bed of the stream is sandy and shifting. The bench mark is the top of the foot guard rail at a distance of 45 feet from the initial point for soundings. Its elevation is 25.58 feet above gage datum. The top of the gage pulley has this same elevation. Gage datum is 2,150 feet above sea level, as determined by carrying an aneroid barometer six times between this point and the railroad station at Richardton.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Heart River near Richardton, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 12	R. Richards and E. F. Chandler.	75	541	2.40	11.10	1,299
June 30 [a]	R. Richards	18	13	1.16	4.42	15
June 30 [a]	do	14	21	.68	4.42	14.5
August 4 [b]	do	1–2	0.13–0.51	.31–1.00	3.90	.2
October 27 [a]	L. L. Wilcox	8	4	.71	4.14	2.8

[a] By wading.

[b] By wading; average of 4 measurements.

Mean daily gage height, in feet, of Heart River near Richardton, N. Dak., for 1904.

Day.	Apr	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	6.80	5.70	4.50	4.40	3.90	4.00	3.90	4.20
2	12.40	5.70	4.50	4.40	3.90	4.00	3.90	4.20
3	17.90	5.60	4.80	4.40	3.90	4.00	3.90	4.20
4	19.30	5.50	4.90	4.40	3.90	4.00	4.00	4.20
5	21.50	5.40	5.00	4.40	3.90	4.00	4.00	4.20
6	20.30	5.20	5.70	4.40	3.90	4.00	4.10	4.20
7	17.10	5.20	6.60	4.40	3.90	4.00	4.10	4.20
8	14.70	5.10	7.10	4.30	3.90	4.00	4.10	4.20
9	12.30	5.00	6.20	4.30	3.90	4.00	4.10	4.20
10	11.30	4.90	6.00	4.30	3.90	4.00	4.10	4.20
11	11.50	4.90	5.80	4.30	3.90	4.00	4.10	4.20
12	11.70	4.80	5.60	4.30	3.90	4.00	4.10	4.20
13	10.40	4.80	5.50	4.30	3.90	4.00	4.10	4.20
14	9.10	4.80	5.40	4.30	3.90	4.00	4.10	4.20
15	8.20	4.70	5.30	4.20	3.90	4.00	4.10	4.20
16	7.70	4.70	5.20	4.20	3.90	4.00	4.10	4.20
17	7.10	4.70	4.90	4.20	3.90	4.00	4.10	4.10
18	6.80	4.70	4.70	4.20	4.00	4.00	4.10	4.10
19	6.60	4.70	4.60	4.10	4.10	4.00	4.10	4.10
20	6.50	4.60	4.50	4.10	4.10	4.00	4.10	4.10
21	6.30	4.60	4.50	4.10	4.10	3.90	4.10	4.10
22	6.10	4.60	4.60	4.00	4.10	3.90	4.10	4.10
23	5.90	4.60	4.80	4.00	4.00	3.90	4.10	4.10
24	5.70	4.60	4.80	4.00	4.00	3.90	4.10	4.10
25	5.70	4.60	4.70	4.00	4.00	3.90	4.10	4.10
26	5.70	4.50	4.60	3.90	3.90	3.90	4.20	4.10
27	5.60	4.50	4.50	3.90	3.90	3.90	4.20	4.10
28	5.60	4.50	4.50	3.90	4.00	3.90	4.20	4.10
29	5.60	4.50	4.40	3.90	4.00	3.90	4.20	4.10
30	5.70	4.50	4.40	3.90	4.00	3.90	4.20	4.10
31	.....	4.50	.....	3.90	4.00	.....	4.20	.....

Rating table for Heart River near Richardton, N. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.90	0.2	4.70	34	5.50	128	6.30	252
4.00	1	4.80	43	5.60	142	6.40	269
4.10	2	4.90	53	5.70	157	6.50	287
4.20	4	5.00	64	5.80	172	6.60	305
4.30	8	5.10	75	5.90	187	6.70	323
4.40	13	5.20	87	6.00	203	6.80	342
4.50	19	5.30	100	6.10	219	6.90	361
4.60	26	5.40	114	6.20	235	7.00	380

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1904 and 1 made in 1903. It is fairly well

defined between gage heights 3.9 feet and 5 feet. Above 5 feet all estimates are based upon a measurement at 11.1 gage height, and can only be considered as rough approximations.

Estimated monthly discharge of Heart River near Richardton, N. Dak., for 1904.

[Drainage area, 1,250 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April[a]	4,115	142	1,128	67,120	0.902	1.01
May	157	19	54.4	3,345	.044	.051
June	400	13	87.6	5,213	.070	.078
July	13	0.2	5.62	346	.0045	.0052
August	2	.2	.64	39	.00051	.00059
September	1	.2	.73	43	.00058	.00065
October	4	.2	2.14	132	.0017	.0020
November	4	2.0	3.07	183	.0025	.0028
The period				76,420		

[a] Discharge estimates April 1–15 are rough approximations.

CANNON BALL RIVER NEAR STEVENSON, N. DAK.

This station was established June 10, 1903, by F. E. Weymouth. It is located one-half mile west-northwest of the post-office at Stevenson, in sec. 20, T. 133 N., R. 82 W., and is about 40 miles south of Mandan, N. Dak. The standard chain gage is located on the left bank. The pulley is fastened to a horizontal timber at a point 10.08 feet from the zero of the scale. The length of the chain from the end of the weight to the end of the chain and ring is 26.09 feet. It is read once each day by Donald Stevenson. Discharge measurements are made from a ¾-inch wire cable and car about 200 feet above the gage. The left end of the cable is supported by a post 3 feet above ground and 10 feet back from the crest of the bank, and is fastened to a 4-foot log anchor buried in the ground. This end of the cable is about 34 feet above gage datum. The right end of the cable is attached to a 13-inch cottonwood tree at a point 12 feet above ground and 30 feet above the gage datum. The tree is guyed by a cable attached to a log anchor buried in the ground. A tag wire, consisting of barbed wire with zinc markers every 10 feet, is stretched above the cable. The initial point for soundings is a point 2 feet back from the cable support on the left bank. The channel is straight for 100 feet above the station and for 400 feet below. The current velocity is sluggish at ordinary stages. The right bank is low and is a gradual

slope up from the water's edge. It is covered with timber and brush. The left bank is steep and about 25 feet high. Bench mark No. 1 is the highest point of a bowlder, whose dimensions are 6 by 8 feet, located in the stream about 600 feet below the gage, toward the right bank. Its elevation above gage datum is 4.84 feet. Bench mark No. 2 is on the post to which the shore end of the horizontal gage rod is attached. It is the top surface of notch in which the gage rod rests. Elevation 15.99 feet above gage zero. Bench mark No. 3 is the top of the projecting pulley carrying the chain. Elevation 15.70 feet above gage zero. The datum of the gage is about 1,700 feet above sea level, as determined by carrying an aneroid barometer six times between this station and Mandan, N. Dak. The drainage area of Cannon Ball River at this station is 3,650 square miles. The bed of the stream consists of clay, soft mud, and loose stones, and is probably somewhat shifting. The depth varies from 2 to 5 feet at ordinary stages.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Cannon Ball River near Stevenson, N. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square ft.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 10	E. F. Chandler	158	686	3.45	7.18	2,366
July 4	Chandler and Richards.	104	156	.46	3.24	72
August 1	E. F. Chandler	37	30	.20	2.65	6
August 1 [a]	R. Richards	34	21	.25	2.64	5.2
October 25 [a]	L. L. Wilcox	7	3.8	.92	2.58	3.5

[a] Measurement made by wading.

Mean daily gage height, in feet, of Cannon Ball River near Stevenson, N. Dak., for 1904.

Day.	Jan. [a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	[b] 7.8	3.7	3.2	3.6	2.6	2.3	2.6	2.8	.....
2	.....	.....	.....	9.1	3.7	[c] 3.6	3.4	2.5	2.2	2.6	2.9	.....
3	.....	.....	.....	.....	3.5	5.7	3.3	2.5	2.2	2.6	2.9	.....
4	.....	.....	.....	.....	3.5	6.6	3.4	2.5	2.3	2.4	2.9	.....
5	.....	.....	.....	[d] 7.8	3.5	6.3	3.1	2.4	2.3	2.4	2.8	.....
6	.....	.....	.....	6.6	3.5	6.2	3.1	2.4	2.2	2.3	2.8	.....
7	.....	.....	.....	7.2	3.4	5.6	3.2	2.4	2.2	2.2	2.8	.....
8	.....	.....	.....	7.3	3.4	3.9	3.1	2.3	2.1	2.2	2.8	.....
9	.....	.....	.....	7.8	3.5	[c] 6.3	3.0	2.3	2.1	2.3	2.9	.....
10	.....	.....	.....	7.5	3.3	[c] 6.7	3.0	2.3	2.0	2.3	2.8	.....
11	.....	.....	.....	6.6	3.3	5.6	3.1	2.2	2.0	2.4	2.7	.....
12	.....	.....	.....	5.7	3.3	5.2	3.2	2.0	2.1	2.6	2.7	.....
13	.....	.....	.....	5.4	3.3	5.0	3.2	2.0	2.1	2.6	2.7	.....
14	.....	.....	.....	5.2	3.3	4.7	3.1	1.8	2.1	2.6	2.7	.....

[a] River frozen over from January 1 to April 4.
[b] Old ice still solid.
[c] Heavy rains.
[d] Ice all out.

Mean daily gage height, in feet, of Cannon Ball River near Stevenson, N. Dak., in 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	.....	.....	.....	4.9	3.4	4.7	2.9	1.8	2.2	2.6	2.6	.....
16	.....	.....	.....	4.2	3.4	4.5	2.9	2.2	2.3	3.1	2.6	.....
17	.....	.....	.....	4.2	3.3	4.2	2.9	[a]2.7	2.3	3.1	2.6	.....
18	.....	.....	.....	4.1	3.3	3.8	2.9	2.9	2.3	3.4	2.4	.....
19	.....	.....	.....	4.2	3.3	3.9	2.7	2.9	2.3	3.4	2.4	.....
20	.....	.....	.....	4.2	3.3	3.9	2.8	2.7	2.4	3.3	2.7	.....
21	.....	.....	.....	4.1	3.2	3.6	2.8	2.7	2.4	2.7	2.7	.....
22	.....	.....	.....	4.1	3.4	3.6	2.6	2.7	2.5	2.6	2.6	.....
23	.....	.....	[b]5.9	4.0	3.4	3.5	2.7	2.6	2.5	2.6	2.6	.....
24	.....	.....	.....	4.0	3.3	3.5	2.7	2.6	2.6	2.6	2.6	.....
25	.....	.....	.....	4.0	3.2	3.6	2.7	2.4	2.6	2.7	2.6	.....
26	.....	.....	.....	3.9	3.2	3.6	2.8	2.3	2.6	2.7	2.6	.....
27	.....	.....	.....	3.9	3.2	3.4	2.7	2.3	2.7	2.7	2.7	.....
28	.....	.....	.....	3.7	3.1	3.3	2.7	2.3	2.7	2.6	2.7	.....
29	.....	.....	.....	3.7	3.0	3.2	2.6	2.4	2.6	2.6	2.7	.....
30	.....	.....	.....	3.7	3.0	3.1	2.6	2.4	2.6	2.8	(c)	.....
31	.....	.....	[b]6.8	.....	3.2	.....	2.6	2.3	.....	2.8	.....	.....

[a] Heavy rains.
[b] Water on top ice.
[c] River frozen over from November 29 to December 31, inclusive.

GRAND RIVER NEAR SEIM, S. DAK.

This station was established June 6, 1904, by F. M. Madden. It is located just below the junction of North and South forks of Grand River, near Seim, S. Dak. An inclined gage in two sections graduated to read direct to feet and tenths is fastened to a tree and posts set into the left bank. It is read daily by James McGee. Discharge measurements are made by wading or by the use of floats during high water. The initial point for soundings is the 3-foot mark of the gage. The channel is curved for about 200 feet above and 300 feet below the station, and the current is swift. The right bank is low, covered with scattering trees, and is subject to overflow. The left bank is high, clean, and does not overflow. The bed of the stream is composed of sand and gravel, free from vegetation, and permanent. There is but one channel at high water. During low stages there are three channels above and one below the gage. The slope of the channel is 5.89 feet to the mile, as determined from a 600-foot section at station. Bench mark No. 1 is a railroad spike in the tree to which the upper portion of the gage is attached. Its elevation is 9.10 feet above the zero of the gage. Bench mark No. 2 is a railroad spike driven into a cottonwood tree 125 feet from the left bank opposite the gage. Its elevation is 14.08 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Grand River near Seim, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec. feet.*
June 6	F. M. Madden	130	171	2.58	3.45	441
July 14 [a]	do	20	6.5	.69	1.60	4.5

[a] 50 feet above station.

Mean daily gage height, in feet, of Grand River near Seim, S. Dak., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		2.1				
2		2.1				
3		2.1				
4		2.1				
5		2.1				
6	3.45	2.1				
7	3.0	2.1				
8	4.0	2.1				
9	3.9	2.1				
10	3.6	2.1				
11	3.1	2.1				
12	2.3	2.1				
13	2.3	2.1				
14	2.3	1.6				
15	2.2	(a)				
16	2.2	1.6				
17	2.2	1.6				
18	2.2	1.6				
19	2.2	1.6				
20	2.2	1.6				
21	2.2	(a)				
22	2.1					
23	2.1					
24	2.1					
25	2.1					
26	2.1					
27	2.1					
28	2.1					
29	2.1					
30	2.1					
31						

[a] Water below gage July 15 and from July 21 to November 19.

MOREAU RIVER NEAR BIXBY, S. DAK.

This station was established June 4, 1904, by F. M. Madden. It is located about 1,000 feet below the ford one-fourth mile southeast of Bixby, S. Dak. A plain staff gage is driven in an inclined position as far as possible into the bed of the stream and firmly spiked to two

small trees upon the right bank. In order to read gage heights in floods, the gage is continued on a large cottonwood tree, 50 feet from the lower rod, and divided so as to read direct. The gage is read once each day by J. A. Hudgins. Discharge measurements are made at ordinary stages by wading, and at flood water by means of floats. The initial point for soundings is the 7-foot mark on the gage. The channel is straight for about 300 feet above and curved for 300 feet below the station. The current is swift, becoming sluggish below the station at low water. The right bank is high, timbered, and does not overflow. The left bank is timbered and subject to overflow in extreme high water. The bed of the stream, composed of sandstone, containing much clay and fine sand, is free from vegetation and permanent. There is but one channel at all stages. Bench mark No. 1 is a railroad spike driven into and near the base of a cottonwood tree 75 feet from the gage on the right bank. Its elevation is 13.98 feet above the zero of the gage. Bench mark No. 2 is a railroad spike driven into and near the base of a cottonwood tree 100 feet from the gage and 75 feet downstream from the first bench mark. Its elevation is 13.95 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Moreau River near Bixby, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 4 [a]	F. M. Madden	86	225	2.80	3.6	631
June 7 [a]	do	87	251	3.07	3.9	771
June 8 [a]	do	85	199	2.66	3.3	530
July 12	do	46	10	1.00	1.5	10
July 12	do	82	117	1.22	2.25	143

[a] Flood measurement.

Mean daily gage height, in feet, of Moreau River near Bixby, S. Dak., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	1.4	1.2	1.8	1.3	1.3
2	.....	1.4	1.2	4.0	1.3	1.3
3	.....	1.4	1.2	2.7	1.3	1.3
4	.....	1.4	1.2	2.0	1.2	1.3
5	3.0	1.4	1.1	1.8	1.2	1.3
6	4.6	1.5	1.1	1.7	1.2	1.3
7	4.3	1.5	1.1	1.6	1.2	1.3
8	3.0	1.6	1.0	1.6	1.2	1.3
9	3.8	1.6	1.0	1.5	1.2	1.3
10	3.8	1.5	1.0	1.5	1.2	1.3
11	4.1	1.5	1.0	1.5	1.2	1.3
12	2.8	2.0	1.0	1.5	1.2	1.3
13	2.3	2.0	1.0	1.4	1.2	1.3
14	2.0	2.0	1.0	1.4	1.2	1.3
15	2.0	1.7	1.0	1.3	1.2	1.3
16	1.9	1.6	1.0	1.3	1.2	1.3
17	1.8	1.5	1.0	1.3	1.2	1.3
18	1.7	1.5	1.0	1.3	1.2	1.3
19	1.7	1.5	1.0	1.3	1.2	1.3
20	1.6	1.5	1.2	1.3	1.2	1.3
21	1.6	1.4	1.3	1.3	1.2	1.3
22	1.5	1.4	1.3	1.3	1.2	1.3
23	1.5	1.4	1.3	1.3	1.2	1.3
24	1.5	1.4	1.2	1.3	1.3	1.3
25	1.5	1.3	1.2	1.3	1.3	1.3
26	1.5	1.3	1.1	1.3	1.3	1.3
27	1.5	1.3	1.1	1.3	1.3	(a)
28	1.5	1.3	1.1	1.3	1.3	.....
29	1.5	1.3	1.1	1.3	1.3	.....
30	1.4	1.3	1.1	1.3	1.3	.....
31	.....	1.2	1.3	.....	1.3	.....

[a] Frozen November 27.

Rating table for Moreau River near Bixby, S. Dak., from June 5 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.30	0	2.00	84	2.90	340	3.80	722
1.35	2	2.10	104	3.00	378	3.90	770
1.40	4	2.20	128	3.10	418	4.00	818
1.45	7	2.30	156	3.20	458	4.10	866
1.50	10	2.40	184	3.30	500	4.20	914
1.60	18	2.50	212	3.40	544	4.30	966
1.70	30	2.60	240	3.50	588	4.40	1,018
1.80	46	2.70	272	3.60	632	4.50	1,070
1.90	64	2.80	304	3.70	676	4.60	1,122

The preceding table is applicable only for open-channel conditions. It is based upon 5 discharge measurements made during 1904. It is fairly well defined between gage heights 1.5 feet and 4 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Moreau River near Bixby, S. Dak., for 1904.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
June 5–30	1,122	4	234	12,070
July	84	0	14.6	898
August	0	0	.0	0
September	818	0	46.0	2,737
October	0	0	.0	0
November	0	0	.0	0

CHEYENNE RIVER AT EDGEMONT, S. DAK.

This station was established June 19, 1903, by R. F. Walter. It is located at the highway bridge just downstream from the Burlington and Missouri River Railroad bridge. It is just above the junction of Cottonwood Creek and Cheyenne River. The gage is a vertical 2 by 4 inch timber graduated to feet and tenths, and fastened by bolts and iron bands to the downstream side of the middle steel pier of the bridge. The observer to September 1 was Loyd Stewart, who read the gage once each day. Hebert Wiedenfeld has beenthe observer since September 1, 1904. Discharge measurements are made from the highway bridge. The initial point for soundings is a brass-headed tack surrounded by four similar tacks in the first post of the hand rail on the west end of the bridge. The channel is straight above and below the station, and the current velocity is low. The right bank is high enough to prevent overflow, and is cleared. The left bank is low and subject to overflow; it has a few scattered trees. The bed of the stream is sandy and shifting. The water flows in two channels at low water and in one at high stages. Bench mark No. 1 is a nail surrounded by a circle of brass tacks driven into a knot on the south side of a cottonwood tree 250 feet north of the north end of the wagon bridge. Its elevation above the zero of the gage is 11.29 feet. Bench mark No. 2 is the corner of the abutment at the north end of the railroad bridge. It is on the fourth step of the abutment and on the corner on the east side away from the bridge. Its elevation above the zero of the gage is 20.23 feet. The drainage area above the station is 7,350 square miles.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Cheyenne River at Edgemont, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 15	F. M. Madden	29	15	1.4	1.75	21
May 14	do	66	29	1.24	2.00	36
May 26	do	147	266	2.79	3.40	743
June 18	do	146	212	2.48	3.20	526
August 6	do	5.5	1.5	.67	1.35	1
September 16	do	11	3.2	1.06	1.60	3.4

Mean daily gage height, in feet, of Cheyenne River at Edgemont, S. Dak., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.[a]	Dec.[a]
1	.....	2.0	3.5	5.6	2.3	1.7	3.6	1.6	1.5	2.5
2	.....	2.0	3.35	4.9	6.0	1.7	2.8	1.6	1.5	2.5
3	.....	2.0	3.0	8.0	5.55	1.7	2.3	1.6	1.5	2.5
4	.....	2.0	3.65	6.2	3.75	1.7	2.9	1.6	1.5	2.6
5	.....	2.0	3.15	5.0	2.9	1.7	2.4	1.6	1.5	2.6
6	.....	2.0	2.7	3.95	5.3	1.7	2.1	1.6	1.5	2.6
7	.....	2.0	2.6	3.55	4.7	1.7	2.0	1.6	1.5	2.6
8	.....	1.9	2.5	3.3	4.4	1.7	2.0	1.6	1.5	2.6
9	.....	1.9	2.4	5.85	4.2	1.7	1.8	1.6	1.5	2.6
10	.....	1.9	2.3	4.25	4.0	1.6	1.7	1.6	1.5	2.6
11	.....	1.8	2.2	3.7	3.7	1.6	1.7	1.7	1.5	2.6
12	.....	1.8	2.1	3.25	3.5	1.6	1.7	1.8	1.5	2.6
13	.....	1.8	2.0	2.8	4.1	1.6	1.6	2.0	1.6	2.6
14	.....	1.7	2.0	2.4	3.4	1.6	1.5	2.6	1.7	2.6
15	.....	1.7	2.0	2.2	3.0	1.5	1.5	2.7	1.6	2.6
16	2.4	1.7	2.0	3.55	2.7	1.5	1.5	2.5	1.6	2.6
17	2.3	1.7	2.0	3.3	2.5	1.5	1.5	2.4	1.5	2.6
18	2.2	1.7	2.0	2.8	2.3	1.5	1.5	2.2	1.5	2.6
19	2.0	1.7	2.0	2.4	2.1	1.5	1.4	2.0	1.5	2.6
20	2.0	1.7	2.0	2.2	2.0	1.5	1.4	1.7	1.5	2.6
21	2.0	1.7	6.4	2.1	2.0	1.5	1.4	1.7	1.8	2.6
22	2.0	1.6	5.7	3.8	1.9	1.4	1.4	1.7	1.8	2.6
23	2.0	1.6	4.8	3.4	2.0	1.4	1.4	1.7	2.0	2.6
24	2.0	1.6	3.8	3.0	1.9	1.4	1.4	1.6	2.2	2.6
25	2.0	1.5	3.55	2.6	1.8	1.4	1.4	1.6	2.3	2.6
26	2.0	1.5	3.35	2.4	1.8	1.4	1.4	1.6	2.3	2.6
27	2.0	1.5	3.2	2.9	1.7	1.4	1.4	1.6	2.4	2.6
28	2.0	1.5	3.1	2.7	1.7	1.4	1.9	1.6	2.4	2.6
29	2.0	1.5	3.0	2.6	1.7	1.4	1.9	1.6	2.4	2.6
30	2.0	1.5	2.9	2.5	1.7	3.4	1.7	1.5	2.4	2.6
31	2.0	.....	3.2	.....	1.7	4.2	.....	1.5	.....	2.6

[a] River frozen November 27 to December 31.

SPRING CREEK NEAR RAPID, S. DAK.

This station was established June 27, 1903, by R. F. Walter. It is located on the highway from Rapid to Hermosa, on the property of Frank

Blair. The gage is an upright 2 by 4 inch timber spiked to a tree at the water's edge about 100 feet above a small plank footbridge from which measurements of discharge are sometimes made. The gage is read once each day by Lyda Blair. The channel is straight for 100 feet above and 75 feet below the station. The water is sluggish above and below the footbridge, but has a high velocity where measurements are made. Both banks are low and subject to overflow. At the station the bed of the stream is gravelly; above and below this point it has a muddy bottom. Bench mark No. 1 is a steel nail driven into the tree to which the gage is attached. Its elevation is 2.14 feet above the zero of the gage. Bench mark No. 2 is a steel nail driven into the base of a tree about 50 feet upstream from the gage. Its elevation is 4.14 feet above the zero of the gage. Bench mark No. 3 is a steel nail driven into the roots of a tree about 75 feet downstream from the gage. Its elevation is 3.36 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrogapher.

Discharge measurements of Spring Creek near Rapid, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 17 [a]	F. M. Madden	16	11	0.58	0.93	6.4
June 26	do	22	43	2.72	2.10	117
August 15	do	19	21	.67	1.10	14
September 24	do	16	16	.38	.90	6

[a] Measurement by wading.

Mean daily gage height, in feet, of Spring Creek near Rapid, S. Dak., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		0.8	(a)	1.5	1.7	1.2	1.2	0.9	1.0
2		.7	(a)	1.5	1.7	1.2	1.1	.9	1.0
3		(a)	(a)	2.3	1.7	1.2	1.1	.9	1.0
4		(a)	0.7	2.5	1.7	1.2	1.0	.9	1.0
5		(a)	.9	2.5	1.7	1.2	1.0	.9	1.0
6		(a)	.9	2.4	1.7	1.2	1.0	.9	1.0
7		(a)	1.0	2.4	1.7	1.2	1.0	.9	1.0
8		(a)	1.0	2.7	1.6	1.1	1.0	.9	1.0
9		(a)	1.0	2.9	1.5	1.1	1.0	.9	.9
10		(a)	1.0	2.9	1.5	1.1	.9	.9	.7
11		(a)	.9	2.5	1.5	1.1	.9	.9	.9
12		(a)	.9	2.6	1.5	1.1	.9	.9	.9
13		(a)	.9	3.0	[b]3.4	1.1	1.0	.9	.9
14		(a)	.9	2.8	1.8	1.3	.9	1.0	.8
15		(a)	.9	3.0	1.8	1.1	.9	1.0	.9
16		(a)	.9	2.8	1.5	1.1	.9	1.0	.9

[a] Dry. [b] 3 p. m., gage height 4.3 feet; 6 p. m., gage height 2.5 feet.

Mean daily gage height, in feet, of Spring Creek near Rapid, S. Dak., for 1904— Continued.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
17	.....	(a)	0.9	2.6	1.5	1.1	0.9	1.0	0.9
18	0.9	(a)	.9	2.6	1.5	1.1	.9	1.0	.9
19	.9	(a)	.9	2.5	1.5	1.1	.9	1.0	.9
20	.9	(a)	.9	2.5	1.5	1.1	.9	1.0	.9
21	1.0	(a)	1.0	2.4	1.5	1.1	.9	1.0	.9
22	.8	(a)	1.0	2.2	1.5	1.1	.9	1.0	.9
23	1.0	(a)	1.0	2.2	1.4	1.1	.9	1.0	.9
24	.9	(a)	1.3	2.4	1.4	1.0	.9	1.0	.9
25	.5	(a)	1.2	2.3	1.4	1.0	.9	1.0	.8
26	(a)	(a)	1.2	2.1	1.3	1.0	.9	1.0	.8
27	(a)	(a)	1.2	2.0	1.3	1.0	.9	1.0	.8
28	(a)	(a)	1.2	1.9	1.3	1.0	.9	1.0	.9
29	.7	(a)	1.2	1.8	1.3	1.0	.9	1.0	1.0
30	.9	(a)	1.2	1.8	1.3	1.0	.9	1.0	.8
31	.8	.....	1.3	.....	1.2	1.0	.....	1.0	.....

a Dry.

Rating table for Spring Creek near Rapid, S. Dak., from June 27, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	1.0	1.30	29	2.10	117	2.80	222
.60	1.5	1.40	37	2.20	131	2.90	238
.70	2.5	1.50	47	2.30	145	3.00	255
.80	4.0	1.60	57	2.40	160	3.10	272
.90	6.0	1.70	67	2.50	175	3.20	289
1.00	10	1.80	79	2.60	190	3.30	307
1.10	15	1.90	91	2.70	206	3.40	325
1.20	21	2.00	103				

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1903 and 1904. It is not well defined.

Estimated monthly discharge of Spring Creek near Rapid, S. Dak., for 1903 and 1904.

[Drainage area, 205 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
July	29	10	14.8	910	0.072	0.083
August	15	6	10.0	615	.049	.056
September	10	6	6.73	400	.033	.037
October	6	6	6.00	369	.029	.033
November	10	0	4.03	240	.020	.022
December	10	2	5.26	198	.026	.018
The period				2,732		
1904.						
March 18–31	10	0	4.39	122	.021	.011
April	4	0	0.22	13	.0011	.0012
May	29	0	10.6	652	.052	.060
June	255	47	161	9,580	.785	.876
July	325	21	58.5	3,597	.285	.329
August	29	10	15.5	953	.076	.088
September	21	6	8.03	478	.039	.044
October	10	6	8.32	512	.041	.047
November	10	2.5	6.75	402	.033	.037
The period				16,310		

RAPID CREEK AT RAPID, S. DAK.

This station was established June 10, 1903, by R. F. Walter. It is located at a wagon bridge one-half mile downstream from the Rapid River Milling Company's mill and one-fourth mile north of the Fremont, Elkhorn and Missouri Valley Railway. The gage is a vertical 2 by 4 inch timber, securely spiked to a timber at the south abutment of the bridge. It is graduated to feet and tenths by means of brass-headed tacks. The observer, John Merritts, reads the gage twice each day. Discharge measurements are made from the downstream side of the wagon bridge. The initial point for soundings is a brass-headed tack surrounded by four similar tacks driven into the downstream face of the end post at the south end of the bridge. The channel is straight for 150 feet above and 100 feet below the station. The banks are 12 to 15 feet high, and will overflow only at extreme

high water. The bed of the stream is muddy, with embedded bowlders. At high water the stream flows in two channels, one of which is extremely small. The river is subject to rapid fluctuations in height, owing to the opening and closing of head-gates of a power plant above the station. Bench mark No. 1 is the top of a nail driven flush with the surface of the top of a low post at the south end of the bridge. Its elevation above the zero of the gage is 12.73 feet. Bench mark No. 2 is the upper surface of the lowest timber of the front doorsill of a house owned by Mr. Feigel. Its elevation above the zero of the gage is 18.12 feet. This is the first house on the west side of the road going north from the bridge. New bench marks were established at this station in spring of 1904, as the first ones established were apt to be disturbed. Bench mark No. 1, elevation 13.92 above zero of gage, is on a railroad spike driven near the base of the second tree from the southeast corner of dwelling, across the street from the School of Mines dormitory. Bench mark No. 2, elevation 12.81 above zero of gage, is on a railroad spike driven near the base of the first tree from the corner, south of the School of Mines dormitory.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Rapid Creek at Rapid, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 26	F. M. Madden	33	55	0.97	1.7	53
March 28	do	33	55	.91	1.7	50
April 23[a]	do	34	64	2.20	2.2	141
May 18	do	37	60	2.12	2.15	127
June 7	F. C. Magruder	41	131	5.08	3.8	665
June 21	F. M. Madden	35	114	3.80	2.8	433
August 8[b]	do	32	70	1.30	1.65	91
September 17[a]	do	36	49	1.82	1.6	89

[a] Wading. [b] Channel changed.

Mean daily gage height, in feet, of Rapid Creek at Rapid, S. Dak., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				1.95	2.18	2.22	2.45	1.68	1.8	1.55	1.6	1.58
2				1.92	2.20	2.3	2.3	1.62	2.15	1.55	1.6	(b)
3				1.92	2.25	2.5	2.35	1.58	1.85	1.6	1.6	(b)
4				2.0	2.22	2.82	2.32	1.68	1.72	1.48	1.55	(b)
5				2.08	2.2	3.45	2.3	1.62	1.68	1.55	1.55	(b)
6				2.02	2.23	4.3	2.3	1.68	1.48	1.55	1.58	1.48
7				2.0	2.25	3.7	2.3	1.6	1.65	1.55	1.58	1.45
8				2.08	2.25	3.55	2.25	1.52	1.55	1.62	1.5	1.48
9				2.08	2.2	3.5	2.22	1.6	1.58	1.58	1.6	1.55
10				2.08	2.2	3.4	2.18	1.68	1.45	1.58	1.6	1.58
11				2.05	2.2	3.45	2.2	1.5	1.55	1.6	1.58	1.65
12				2.08	2.2	3.4	2.12	1.58	1.6	1.6	1.6	1.5
13				2.1	2.2	3.35	2.28	1.55	1.65	1.65	1.6	1.62
14				2.15	2.2	3.2	2.22	1.6	1.6	1.7	1.58	1.55
15				2.2	2.2	3.12	2.10	1.58	1.52	1.68	1.62	1.48
16				2.2	2.2	3.08	2.08	1.52	1.55	1.65	1.6	1.45
17				2.18	2.2	2.95	2.00	1.55	1.62	1.7	1.62	1.52
18				2.15	2.15	2.85	1.92	1.55	1.45	1.62	1.62	1.38
19				2.15	2.1	2.8	1.92	1.62	1.5	1.68	1.6	1.48
20			1.95	2.15	2.1	2.8	1.88	1.65	1.6	1.62	1.65	1.38
21			1.9	2.12	2.12	2.8	1.90	1.60	1.42	1.6	1.65	1.45
22			1.85	2.15	2.2	2.72	1.88	1.45	1.48	1.62	1.58	1.35
23			1.85	2.15	2.22	2.68	1.85	1.48	1.55	1.6	1.6	1.58
24				2.15	2.22	2.82	1.88	1.48	1.5	1.6	1.62	1.68
25			1.7	2.15	2.25	2.72	1.78	1.48	1.52	1.6	1.62	(b)
26			1.7	2.15	2.25	2.68	1.85	1.45	1.55	1.58	1.6	(b)
27			1.68	2.15	2.25	2.58	1.7	1.45	1.62	1.6	1.6	(b)
28			1.7	2.15	2.25	2.52	1.72	1.38	1.55	1.6	1.5	(b)
29			1.8	2.14	2.2	2.42	1.75	1.38	1.48	1.58	1.62	(b)
30			2.0	2.14	2.2	2.32	1.68	1.5	1.48	1.6	1.55	1.5
31			1.95	.....	2.2	.....	1.75	1.42	.....	1.6	.....	1.62

[a] River frozen January 1 to March 19, inclusive.

[b] Frozen.

Rating table for Rapid Creek at Rapid, S. Dak., from January 1 to June 6, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.70	50	2.10	120	2.50	220	2.80	318
1.80	66	2.20	141	2.60	254	2.90	350
1.90	83	2.30	164	2.70	286	3.00	382
2.00	101	2.40	190				

NOTE.—The flood on June 7, 1904, changed the channel so as to require a new table for the remainder of the year. Neither table is accurate.

The above table is applicable only for open-channel conditions. It is based upon 9 discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 1.7 feet and 2.3 feet. The table has been extended beyond these limits. Above gage height 2.5 feet the rating curve is a tangent, the difference being 32 per tenth.

Rating table for Rapid Creek at Rapid, S. Dak., from June 7 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.40	66	1.90	136	2.30	239	2.70	364
1.50	76	2.00	159	2.40	269	2.80	396
1.60	86	2.10	183	2.50	300	2.90	428
1.70	99	2.20	210	2.60	332	3.00	460
1.80	116						

The above table is applicable only for open-channel conditions. It is based upon 4 discharge measurements made during 1904, and is drawn parallel to the curve for the first part of 1904. It is not well defined. Above gage height 2.5 feet the rating curve is a tangent, the difference being 32 per tenth.

Estimated monthly discharge of Rapid Creek at Rapid, S. Dak., for 1904.

[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 20–31	101	47	70.1	1,668	0.171	0.076
April	141	87	120	7,140	.293	.327
May	153	120	142	8,731	.346	.399
June	798	146	434	25,820	1.06	1.18
July	284	96	175	10,760	.427	.492
August	96	64	81.3	4,999	.198	.228
September	196	68	88.0	5,236	.215	.240
October	99	74	86.8	5,337	.212	.244
November	92	76	85.5	5,088	.209	.233
December [a]	96	62	79.2	4,870	.193	.222
The period				79,650		

[a] River frozen December 2–5 and 25–29. Discharge estimated.

BOX ELDER CREEK AT BLACKHAWK, S. DAK.

This station was established June 27, 1903, by R. F. Walter. It is located at the bridge on the road leading past the church at Blackhawk. It is about 2 miles downstream from the point at which Box Elder Creek crosses the road from Rapid to Piedmont. The gage is a vertical timber graduated to feet and tenths and securely spiked to a pile on the upstream side of the east end of the bridge. The gage is read once each day by Roy H. Haedt. Discharge measurements

are best made by wading. The initial point for soundings is a brass tack driven into the hand rail vertically above the gage. The channel is straight for 150 feet above the station and curved for 75 feet below. Both banks are high and cleared, but may overflow in extremely high water. The bed of the stream is stony, with soft mud along the edges. There is considerable water grass just below the station. Bench mark No. 1 is a steel spike driven in a large fence post, about 6 inches above its base, at the corner of the barnyard, 300 feet east of the station. Its elevation is 16.84 feet above the zero of the gage. Bench mark No. 2 is a steel spike driven into the south gatepost, about 6 inches above its base. This gate is located near a house about 500 feet from the station, along the road toward Rapid. The elevation of the bench mark above the zero of the gage is 16.81 feet. Bench mark No. 3 is on drift bolt driven in base of large cottonwood tree on right bank, about 75 feet upstream from bridge, and its elevation is 4.34 feet above zero of gage. The drainage area above the station is 157 square miles.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Box Elder Creek at Blackhawk, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec. feet.*
June 7	F. C. Magruder	47	170	2.22	3.80	377
June 26[a]	F. M. Madden	39	74	1.23	1.90	91
August 15	do	12	5.7	.79	.70	4.5
September 24	do	12	7.3	.64	.82	4.7

[a] Drift interfered with flow.

Mean daily gage height, in feet, of Box Elder Creek at Blackhawk, S. Dak., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec
1		0.95	1.35	1.65	0.95	0.75	0.83	0.68	0.75
2		1.0	1.4	1.6	.95	.75	.83	.65	.75
3		1.05	1.4	1.6	.95	.75	.85	.65	.75
4		1.3	1.85	1.6	.9	.75	.85	.65	.....
5		1.3	4.25	1.65	.9	.78	.85	.65	.....
6		1.3	4.5	1.6	.85	.78	.85	.65	.....
7		1.2	3.9	1.55	.85	.75	.85	.65	.....
8		1.3	3.65	1.5	.85	.75	.85	.65	.....
9		1.3	3.45	1.43	.85	.75	.85	.65	.....
10		1.3	3.4	1.4	.8	.85	.85	.65	.....
11		1.3	3.35	1.6	.8	.88	.85	.65	.....
12		1.3	3.05	1.55	.75	.9	.85	.65	.....
13		1.3	2.9	1.65	.75	.9	.83	.65	.....
14		1.35	2.75	1.55	.75	.9	.83	.65	.....

Mean daily gage height, in feet, of Box Elder Creek at Blackhawk, S. Dak., for 1904— Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	.....	1.3	2.68	1.45	0.7	0.9	0.83	0.65	.....
16	.....	1.25	2.6	1.3	.7	.9	.83	.65	.....
17	.....	1.2	2.4	1.3	.7	.9	.83	.65	.....
18	0.8	1.1	2.25	1.2	.75	.88	.83	.65	.....
19	.8	1.1	2.2	1.15	.75	.85	.8	.65	.....
20	.95	1.1	2.15	1.1	.75	.85	.8	.7	.....
21	1.0	1.25	2.15	1.15	.75	.85	.8	.7	.....
22	1.1	1.4	2.1	1.2	.75	.85	.8	.7	.....
23	1.1	1.35	2.0	1.25	.75	.85	.8	.7	.....
24	1.05	1.3	2.3	1.2	.75	.85	.8	.7	.....
25	1.05	1.38	2.2	1.15	.75	.85	.8	.7	.....
26	1.05	1.44	2.0	1.15	.75	.85	.78	.7	.....
27	1.05	1.4	2.0	1.1	.75	.85	.75	.75	.....
28	1.05	1.35	1.8	1.1	.75	.85	.75	.75	.....
29	1.0	1.3	1.75	1.05	.75	.85	.75	.75	.....
30	.95	1.3	1.7	1.0	.75	.83	.73	.75	.....
31	.....	1.3	.....	.95	.75	.....	.7	.....	.....

NOTE: River frozen January 1 to April 17 and December 4 to 31.

Rating table for Box Elder Creek at Blackhawk, S. Dak., from June 27, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.55	0.0	1.30	31	2.40	154	3.50	326
.60	.5	1.40	39	2.50	168	3.60	342
.65	1.0	1.50	47	2.60	182	3.70	358
.70	1.5	1.60	57	2.70	198	3.80	374
.75	2.5	1.70	67	2.80	214	3.90	392
.80	4	1.80	78	2.90	230	4.00	410
.85	6	1.90	90	3.00	246	4.10	428
.90	8	2.00	102	3.10	262	4.20	446
.95	10	2.10	114	3.20	278	4.30	464
1.00	12	2.20	126	3.30	294	4.40	482
1.10	17	2.30	140	3.40	310	4.50	500
1.20	23						

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1903 and 1904. It is fairly well defined.

Estimated monthly discharge of Box Elder Creek at Blackhawk, S. Dak., for 1903 and 1904.

[Drainage area, 157 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
July	31	8	14.6	898	0.093	0.107
August	17	8	10.6	652	.068	.078
September	8	4	6.60	393	.042	.047
October	4	.5	2.71	167	.017	.020
November	.5	.5	.50	30	.0032	.0036
The period				2,140		
1904.						
April 18–30	17	4	12.0	309	.076	.037
May	42	10	28.5	1,752	.182	.210
June	500	35	182	10,830	1.16	1.29
July	62	10	36.2	2,226	.231	.266
August	10	1.5	4.03	248	.026	.030
September	8	2.5	5.46	325	.035	.039
October	6	1.5	4.62	284	.029	.033
November	2.5	1.0	1.33	79	.0085	.0095
The period				16,050		

BELLE FOURCHE RIVER AT BELLE FOURCHE, S. DAK.

This station was established May 26, 1903, by R. F. Walter. It is located at the county highway bridge on the western outskirts of Belle Fourche, S. Dak. The gage consists of a 2 by 4 inch vertical timber spiked to a pile on the north side of the bridge on the third bent from the east end. It is graduated to feet and tenths. The footmarks are copper figures and the tenths are marked with brass tacks. The gage is read twice each day by Raymond Giles. Discharge measurements are made from the north side of the bridge. The initial point for soundings is the center of the north pile in the first bent on the east side. The channel is straight for about 225 feet above the station and for 300 feet below. The current is swift. The left bank is high, with a few scattered trees. The right bank is low and subject to overflow at flood stages. It is sparsely wooded. The bed of the stream is of gravel and is permanent. The water flows in a single channel except at low stages, when it is divided by a gravel bar below

the bridge. The original bench mark No. 1 was a spike in a cottonwood tree on the east bank 50 feet downstream from the bridge. Its elevation was 8.016 feet above the zero of the gage. On May 21, 1904, this spike was removed and a railroad spike was driven into the same tree about a foot above the base. Its elevation is 8.05 feet above the zero of the gage. Bench mark No. 2 is the top of the iron breakwater on the east pier of the railroad bridge, which is 300 feet below the highway bridge. Its elevation is 8.13 feet above the zero of the gage. The drainage area above the station is 3,250 square miles. A United States Geological Survey standard bench-mark post located in the Butte County court-house yard has an elevation of 3,011.345 feet above sea level, and is 18.70 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Belle Fourche River at Belle Fourche, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 19	F. M. Madden	121	194	3.07	3.30	596
March 22	do	121	186	2.81	3.10	523
March 29	do	82	85	1.94	2.15	165
April 12	do	90	92	1.80	2.22	166
May 19[a]	do	73	112	1.48	2.10	166
May 21[a]	do	64	90	1.83	2.10	165
May 24	do	100	176	2.45	2.78	431
May 25	W. C. Woods	126	380	3.78	4.45	1,436
June 3	F. C. Magruder	135	491	4.71	5.60	2,314
June 5	do	141	1,166	4.67	10.55	5,444
June 10	do	135	424	4.69	5.10	1,987
July 1	F. M. Madden	92	124	2.61	2.60	324
July 20[a]	do	80	70	1.43	1.80	100
July 30	do	58	48	1.62	1.55	78
August 17[a]	do	17	12	2.17	1.10	26
August 30[a]	do	20	18	3.44	1.50	62

[a] Wading at different sections.

Mean daily gage height, in feet, of Belle Fourche River at Belle Fourche, S. Dak., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				3.05	2.1	2.32	2.65	1.45	1.75	1.35	1.45	1.65
2				3.08	2.95	3.08	2.48	1.4	1.7	1.35	1.45	1.55
3				2.88	3.4	5.18	2.5	1.35	2.1	1.35	1.45	1.52
4				2.8	3.08	6.98	2.45	1.32	2.0	1.35	1.45	1.5
5				2.92	2.7	10.2	2.4	1.32	1.9	1.35	1.45	1.5
6				3.02	2.6	10.88	2.35	1.3	1.78	1.35	1.45	1.5
7				2.88	2.6	10.1	2.35	1.3	1.7	1.35	1.45	1.58
8				2.82	2.85	7.62	2.3	1.25	1.62	1.35	1.45	1.58
9				2.85	2.55	6.3	2.2	1.22	1.52	1.35	1.45	1.65
10				2.78	2.62	5.1	2.2	1.2	1.5	1.35	1.45	1.65
11			[c]5.0	2.45	2.52	4.88	2.48	1.15	1.5	1.35	1.45	1.65
12			5.0	2.3	2.38	4.58	2.18	1.12	1.5	1.35	1.45	1.65
13			4.8	2.35	2.38	3.9	2.02	1.10	1.5	3.5	1.45	1.65
14			4.7	2.35	2.35	3.78	2.00	1.10	1.5	2.75	1.55	1.65
15			4.5	2.4	2.3	3.5	1.95	1.10	1.5	2.75	1.65	1.65
16			4.2	2.4	2.12	3.88	1.9	1.10	1.5	1.75	1.65	1.65
17			3.78	2.5	2.15	3.42	1.9	1.15	1.5	1.7	1.65	1.65
18			3.48	2.4	2.08	3.52	1.85	1.2	1.48	1.65	1.65	1.6
19			3.3	2.35	2.05	3.28	1.8	1.2	1.42	1.65	1.65	1.55
20			3.3	2.28	2.05	3.08	1.8	1.2	1.38	1.6	1.55	[b]1.48
21			3.2	2.22	2.05	2.98	1.78	1.2	1.35	1.6	1.55	[b]1.48
22			3.08	2.22	2.05	2.9	1.75	1.2	1.35	1.6	1.65	[b]1.52
23			3.0	2.35	2.1	2.8	1.72	1.2	1.35	1.6	1.65	[b]1.62
24			3.0	2.3	3.45	2.85	1.72	1.3	1.35	1.6	1.65	[b]1.68
25			2.7	2.28	4.7	2.7	1.7	1.25	1.35	1.58	1.65	[b]1.72
26			2.62	2.25	4.42	2.7	1.65	0.9	1.35	1.55	1.65	[b]1.82
27			2.4	2.15	3.1	3.28	1.58	1.0	1.35	1.55	1.65	[b]1.75
28			2.38	2.0	2.8	2.98	1.55	1.22	1.35	1.5	1.65	[b]1.75
29			2.3	2.0	2.58	2.8	1.55	1.28	1.35	1.5	1.65	[b]1.75
30			2.95	2.02	2.52	2.78	1.55	1.68	1.35	1.5	1.65	[b]1.75
31			2.8		2.38		1.5	1.82		1.4		[b]1.78

[a] Ice January 1 to March 10, inclusive. [b] Ice. [c] Gage heights estimated March 11–15.

Rating table for Belle Fourche River at Belle Fourche, S. Dak., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.90	15	2.10	158	3.30	635	5.00	1,825
1.00	20	2.20	181	3.40	705	5.20	1,965
1.10	26	2.30	206	3.50	775	5.40	2,105
1.20	33	2.40	234	3.60	845	5.60	2,245
1.30	41	2.50	265	3.70	915	5.80	2,385
1.40	50	2.60	299	3.80	985	6.00	2,525
1.50	61	2.70	336	3.90	1,055	6.50	2,875
1.60	73	2.80	376	4.00	1,125	7.00	3,225
1.70	86	2.90	419	4.20	1,265	7.50	3,575
1.80	101	3.00	465	4.40	1,405	8.00	3,925
1.90	118	3.10	515	4.60	1,545	9.00	4,625
2.00	137	3.20	575	4.80	1,685	10.00	5,325

The preceding table is applicable only for open-channel conditions. It is based upon 24 discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.10 feet and 6 feet. The table has been extended beyond these limits. Above gage height 3.30 feet the rating curve is a tangent, the difference being 70 per tenth. It is the same as the 1903 table above 3.0 feet.

Estimated monthly discharge of Belle Fourche River at Belle Fourche, S. Dak., for 1904.

[Drainage area, 3,250 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 11–31[a]	1,825	206	803	33,450	0.247	0.193
April	505	137	277	16,480	.085	.095
May	1,615	147	373	22,930	.115	.133
June	5,941	211	1,495	88,960	.460	.513
July	317	61	148	9,100	.046	.053
August	104	15	38.3	2,355	.012	.014
September	158	45	67.1	3,993	.021	.023
October	775	45	102	6,272	.031	.036
November	79	56	67.8	4,034	.021	.023
December[b]	104	59	77.2	4,747	.024	.028
The period				192,300		

[a] Ice January 1 to March 10.
[b] Ice December 20–31; discharge applied as for open channel.

RED WATER RIVER AT BELLE FOURCHE, S. DAK.

This station was established July 20, 1903, by R. F. Walter. It is located at the county highway bridge in the eastern limits of Belle Fourche, S. Dak. The gage consists of a 2 by 4 inch timber spiked to the west pile of the middle bent of the highway bridge. It is read twice each day by Raymond Giles. Discharge measurements are made from the west side of the bridge. The initial point for soundings is the center of the pile on the west side and at the south end of the bridge. The channel is straight for 50 feet above and below the station and the current is swift. The left bank is high enough to prevent overflow on that side. The right bank, however, is low and subject to overflow. There are trees along both banks. The bed of the stream is rocky and the channel permanent. The water flows in one channel. At very high stages the gage height may be affected by back water from Belle Fourche River. There is considerable "dead water" below the station. Bench mark No. 1 is on the stone water table at the northeast corner of the public school building. Its elevation above the zero of the gage is 26.05 feet. Bench mark No. 2

is the top of the hydrant 75 feet northwest of the public school building. Its elevation above the zero of the gage is 21.83 feet. Bench mark No. 3 is the top point on a stone monument near above-mentioned hydrant. Its elevation is 19.46 feet above the zero of the gage. A United States Geological Survey bench mark in the court-house yard is 3,011.345 feet above mean sea level and is 18.46 feet above zero of gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Red Water River at Belle Fourche, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 22	F. M. Madden	45	143	1.31	3.00	188
March 28	do	45	143	1.31	3.00	188
April 13	do	46	150	1.49	3.15	224
May 13[a]	do	70	70	1.61	2.70	113
June 3	F. C. Magruder	59	169	2.64	3.60	447
June 5	do	90	752	4.90	9.50	7,000
June 6	do	80	578	7.00	7.55	4,044
June 10	do	71	370	3.98	5.00	1,472
June 13	F. M. Madden	70	326	2.23	4.20	726
June 30	do	66	232	1.28	3.40	297
July 20	do	62	188	.60	2.75	113
July 20[a]	do	42	55	1.35	2.55	74
August 30 [a]	do	44	76	2.17	2.90	165

[a] Wading at different sections.

Mean daily gage height, in feet, of Red Water River at Belle Fourche, S. Dak., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				3.02	3.0	2.95	3.4	2.5	2.8	2.95	3.1	3.05
2				3.02	3.0	3.15	3.38	2.5	3.18	2.95	3.1	3.05
3				2.92	3.0	3.5	3.5	2.5	3.05	2.95	3.1	3.05
4				2.98	2.9	5.7	3.32	2.5	3.0	2.95	3.0	3.0
5				2.95	2.78	10.2	3.2	2.5	3.0	2.95	3.0	3.0
6				3.1	2.75	7.4	3.2	2.45	2.95	2.95	3.0	3.0
7				3.2	2.75	5.7	3.2	2.45	2.98	2.95	3.0	3.0
8				3.2	2.7	5.42	3.15	2.5	3.0	2.98	3.0	3.0
9				3.2	2.7	5.42	3.1	2.58	3.0	3.0	3.0	3.0
10			[b]3.2	3.25	2.65	5.0	3.0	2.5	3.0	3.0	3.0	3.05
11			3.2	3.2	2.68	4.58	3.05	2.45	2.9	3.0	3.0	3.05
12			3.2	3.2	2.65	4.42	3.0	2.5	2.95	3.0	3.0	3.05
13			3.2	3.2	2.7	4.25	3.0	2.45	3.0	3.6	3.0	3.05
14			3.2	3.2	2.65	4.1	3.0	2.65	3.0	3.45	3.0	3.05
15			3.1	3.2	2.65	4.02	2.95	2.65	2.98	3.1	3.02	3.05

[a] Ice January 1 to March 9, inclusive.
[b] Gage heights estimated, March 10 to 13, inclusive.

Mean daily gage height, in feet, of Red Water River at Belle Fourche, S. Dak., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16	.....	.....	3.15	3.2	2.65	3.98	2.92	2.65	2.95	3.1	3.05	3.05
17	.....	.....	3.05	3.2	2.62	3.85	2.85	2.7	2.95	3.1	3.05	3.05
18	.....	.....	3.02	3.15	2.6	3.8	2.8	2.7	3.0	3.1	3.05	3.05
19	.....	.....	3.05	3.00	2.58	3.72	2.8	2.7	2.95	3.1	3.05	3.05
20	.....	.....	3.05	3.02	2.55	3.7	2.75	2.7	2.98	3.1	3.05	[a]3.05
21	.....	.....	3.0	3.0	2.65	3.7	2.82	2.7	2.95	3.05	3.05	[a]3.05
22	.....	.....	2.95	3.0	2.9	3.65	2.88	2.7	2.98	3.05	3.05	[a]3.05
23	.....	.....	3.0	3.3	2.92	3.6	2.72	2.68	2.95	3.15	3.05	[a]3.1
24	.....	.....	3.02	3.3	3.1	3.92	2.7	2.62	2.95	3.15	3.05	[a]3.18
25	.....	.....	3.08	3.2	3.3	3.7	2.7	2.6	2.95	3.1	3.0	[a]3.28
26	.....	.....	3.22	3.08	3.28	3.6	2.65	2.6	2.95	3.1	3.0	[a]3.32
27	.....	.....	3.1	3.05	3.1	3.58	2.75	2.6	2.95	3.1	3.0	[a]3.3
28	.....	.....	3.1	3.00	2.98	3.52	2.65	2.6	2.95	3.1	3.0	[a]3.3
29	.....	.....	3.0	3.05	2.92	3.45	2.65	2.7	2.95	3.1	3.0	[a]3.3
30	.....	.....	3.0	3.05	2.92	3.40	2.55	2.95	2.95	3.1	3.0	[a]3.3
31	.....	.....	3.02	.....	2.9	.....	2.55	2.8	.....	3.1	.....	[a]3.3

[a] Ice.

Rating table for Red Water River at Belle Fourche, S. Dak., from January 1, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.40	57	3.40	313	4.30	817	5.20	1,674
2.50	72	3.50	349	4.40	898	5.30	1,776
2.60	90	3.60	390	4.50	984	5.40	1,878
2.70	111	3.70	436	4.60	1,074	5.50	1,980
2.80	134	3.80	487	4.70	1,168	5.60	2,082
2.90	160	3.90	543	4.80	1,266	5.70	2,184
3.00	188	4.00	604	4.90	1,368	5.80	2,286
3.10	217	4.10	670	5.00	1,470	5.90	2,388
3.20	247	4.20	741	5.10	1,572	6.00	2,490
3.30	279						

The above table is applicable only for open-channel conditions. It is based upon 17 discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.4 feet and 5 feet. The table has been extended beyond these limits. Above gage height 4.9 feet the rating curve is a tangent, the difference being 102 per tenth.

Estimated monthly discharge of Red Water River at Belle Fourche, S. Dak., for 1904.

[Drainage area, 1,015 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 10–31 [a]	253	174	213	9,295	0.210	0.172
April	279	166	222	13,210	.219	.244
May	279	81	144	8,854	.142	.164
June	8,050	174	1,096	65,220	1.08	1.20
July	349	81	177	10,880	.174	.201
August	174	65	92.5	5,688	.091	.105
September	241	134	180	10,710	.177	.198
October	390	174	212	13,030	.209	.241
November	217	188	195	11,600	.192	.214
December [b]	286	188	218	13,400	.215	.248
The period				161,900		

[a] Ice conditions January 1 to March 9.
[b] Ice conditions December 20–31; discharge applied as for open channel.

NOTE.—The water at this station joins that from the Belle Fourche station and together they constitute the available supply for the Belle Fourche project.

SPEARFISH CREEK NEAR SPEARFISH, S. DAK.

This station was established March 30, 1904, by F. M. Madden. It is located at the bridge of the Burlington Railway, at Bradley's ranch, about 1 mile above Spearfish, S. Dak. It replaces the temporary station maintained during a part of the year 1903 at Toomey's ranch, 6 miles from Spearfish, and was placed at this point to get above the ditches which take water from Spearfish Creek for the town of Spearfish. A plain staff gage, graduated to feet and tenths, is spiked vertically to a pile supporting the bridge near the right bank on the downstream side. The gage is read once each day by B. F. Bradley. Discharge measurements are made by wading near the gage. In case of extreme high water they could be made from the bridge to which the gage is attached. The channel is very crooked, and the current is swift and full of rapids. Both banks are low, covered with trees and brush, and overflow only when the stream freezes and the water runs over the ice. The bed of the stream is composed of coarse gravel and cobblestones, not subject to much change. There is but one channel at all stages. Bench mark No. 1 is a 12-inch driftbolt driven into the base of a cottonwood tree on the bank of the stream 50 feet below the gage. Its elevation above the zero of the gage is 4.02. Bench mark No. 2 is on the top of the head of a bolt in a pile in the first bent from the gage. The bolt is marked by a spike driven through a flaw in the washer. Its elevation above the zero of the gage is 6.25 feet.

The observations at this station, during 1904, have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Spearfish Creek near Spearfish, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 30	F. M. Madden	26	21	3.43	0.75	72
April 14	do	26	32	4.00	1.00	128
May 25	do	36	36	4.14	1.10	149
June 17	do	28	51	5.71	1.55	291
August 3	do	20	25	3.60	1.00	90
September 15	do	24	24	3.33	1.00	80

Mean daily gage height, in feet, of Spearfish Creek near Spearfish, S. Dak., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		0.75	1.1	1.1	1.25	1.05	1.05	1.0	0.95	0.95
2		.75	1.05	1.15	1.25	1.0	1.05	1.0	.95	.95
3		.75	1.05	1.25	1.35	1.0	1.05	.95	.95	.95
4		.8	1.05	6.35	1.25	.95	1.0	.95	.95	.95
5		.85	1.05	6.0	1.25	.95	.95	1.0	.95	.95
6		.9	1.05	2.2	1.25	.95	1.0	1.0	.95	.95
7		.9	1.05	2.2	1.25	.95	1.0	1.0	.95	.95
8		.85	1.05	2.15	1.15	.95	1.0	1.0	.95	.95
9		.8	1.05	2.2	1.15	.95	1.0	1.0	.95	.95
10		.85	1.05	2.05	1.15	.95	1.05	1.0	.95	.95
11		.9	1.05	1.85	1.15	.95	1.05	1.0	.95	.95
12		.9	1.05	1.8	1.15	.95	1.0	1.0	.95	.95
13		.9	1.05	1.75	1.15	.95	1.0	1.05	.95	1.0
14		1.0	1.05	1.75	1.15	.95	1.0	1.05	.95	1.0
15		1.05	1.05	1.7	1.15	.95	1.0	1.05	.95	1.0
16		1.0	1.05	1.55	1.1	.95	1.0	1.05	.95	.95
17		.95	1.00	1.55	1.05	.95	1.0	1.05	.95	.95
18		.95	1.00	1.5	1.05	.95	1.0	1.0	.95	.95
19		.95	.95	1.5	1.05	.95	1.0	1.0	.95	.95
20		.95	.95	1.5	1.05	.95	1.0	1.0	.95	.95
21		1.05	1.05	1.45	1.05	.95	.95	1.0	.95	.95
22		1.1	1.05	1.4	1.05	.95	.95	1.0	.95	.9
23		1.05	1.1	1.35	1.05	.95	.95	.95	.95	.9
24		1.05	1.15	1.45	1.05	.95	.95	.95	1.0	.9
25		1.0	1.15	1.35	1.05	.95	.95	.95	1.0	.8
26		1.0	1.15	1.35	1.05	.95	.95	.95	.95	.75
27		1.05	1.1	1.3	1.05	.95	.95	.95	.95	.8
28		1.05	1.05	1.25	1.05	.95	.95	.95	.95	[a]1.05
29		1.1	1.05	1.3	1.05	.95	.95	.95	.95	1.05
30	0.75	1.1	1.05	1.25	1.05	.95	.95	.95	.95	1.0
31	.75		1.05		1.05	.95		.95		.95

[a] Ice gorge December 28 to 31.

Rating table for Spearfish Creek near Spearfish, S. Dak., from January 1 to June 30, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Foot.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.70	61	1.00	125	1.60	306	2.10	514
.75	70	1.10	149	1.70	344	2.20	558
.80	80	1.20	175	1.80	384	2.30	604
.85	91	1.30	203	1.90	426	2.40	652
.90	102	1.40	235	2.00	470	2.50	700
.95	113	1.50	270				

The above table is applicable only for open-channel conditions. It is based upon 4 discharge measurements made during 1904. It is well defined between gage heights 0.75 foot and 1.55 feet. The table has been extended beyond these limits. A change in channel because of the formation of a gravel bar at the station necessitates new rating curve from July to December.

Rating table for Spearfish Creek near Spearfish, S. Dak., from July 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Foot.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.80	50	0.95	75	1.10	105	1.30	150
.85	57	1.00	85	1.20	127	1.40	178
.90	65						

The above table is applicable only for open-channel conditions. It is based upon 2 discharge measurements made during 1904, and is drawn parallel to the curve for the first part of the year. Discharges for this period are only roughly approximate.

Estimated monthly discharge of Spearfish Creek near Spearfish, S. Dak., for 1904.

[Drainage area, 230 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	149	70	112	6,664	0.487	0.543
May	162	113	138	8,485	.600	.692
June	4,150	149	550	32,730	2.39	2.67
July	164	95	111	6,825	.483	.557
August	95	75	76.3	4,692	.332	.383
September	95	75	83.0	4,939	.361	.403
October	95	75	83.1	5,110	.361	.416
November	85	75	75.7	4,504	.329	.367
December [a]	85	44	69.2	4,255	.301	.347
The period				78,200		

[a] Discharge from December 28 to 31, assumed 50 second-feet.

OWL CREEK NEAR BELLE FOURCHE, S. DAK.

This station was established May 6, 1904, by F. M. Madden as a flood water station. It is located at the highway bridge, about 2 miles below the proposed Owl Creek reservoir, Belle Fourche project, 12 miles northeast of Belle Fourche, S. Dak. The gage is a plain, vertical staff, spiked to a pile at the downstream side of the bridge. The gage is read only at the time of making discharge measurements. Discharge measurements are made by wading or from the bridge to which the gage is attached. The initial point for soundings is a spike driven into the downstream end of the cap of the right abutment. The channel is straight for about 50 feet above and 200 feet below the station, and the current is swift. Both banks are high, and overflow only during extremely high stages. The slopes of the banks are lined almost to the bottom of the channel with brush. The bed of the stream is composed of soft mud, free from vegetation, and is permanent. There is but one channel, broken at high stages by the piling piers of the bridge. Bench mark No. 1 is a United States Geological Survey standard bench-mark post along the road, about 400 feet to the left of the stream. Its elevation is 2,933 feet above mean sea level and 67.62 feet above the zero of the gage. Bench mark No. 2 is a railroad spike driven into the base of a cottonwood tree, about 150 feet below the bridge, on the right bank of the stream. Its elevation is 15.91 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Owl Creek near Belle Fourche, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 6	F. M. Madden	5	1.8	0.94	0.50	1.7
May 25[a]	F. C. Magruder	53	352	3.16	8.80	1,114
May 26[a]	do	38	207	2.71	5.70	561
June 1	F. M. Madden	8	3.6	2.36	.95	8.5

[a] Float measurement.

RED WATER CANAL AT MINNESELA, S. DAK.

This station was established May 7, 1904, by F. M. Madden for determining the duty of water under this canal. It is located on the bridge across the canal in the town of Minnesela, about 4 miles southeast of Belle Fourche. A vertical staff gage, graduated to feet and tenths, is fastened to the bridge. It is read twice each day by Robert Mitchell. Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is a spike in the bridge over the edge of the canal at the right bank, downstream side. The channel is straight for about 200 feet above and

below the station. The current is medium. The bed of the stream is composed of soft mud, covered with water grass, which in the late summer lessens the flow of the canal considerably. There is but one channel at all stages. The bench mark is a spike in the base of a tree on the left bank of the canal, about 50 feet from the gage. Its elevation is 4.06 feet below the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Red Water canal at Minnesela, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 7	F. M. Madden	17	28	1.46	2.70	41
May 28	do	17	37	1.92	3.15	71
July 5	do	17	33	1.82	3.00	60
September 12 [a]	do	16	31	1.48	3.00	46

[a] Grass grown in canal.

Mean daily gage height, in feet, of Red Water canal at Minnesela, S. Dak., for 1904.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.08	2.5	3.5	2.6	2.7
2	.....	2.58	2.6	3.5	2.6	2.75
3	.....	2.0	2.45	3.5	2.6	2.7
4	.....	2.0	2.75	3.5	2.7	2.65
5	.....	2.0	3.02	3.5	2.7	2.65
6	.....	2.0	3.05	3.5	2.7	2.6
7	.....	2.0	3.05	3.5	3.0	2.6
8	[a] 2.75	2.0	3.05	3.3	3.3	2.58
9	2.7	1.8	3.05	3.5	3.5	2.45
10	2.7	1.65	3.05	3.5	3.0	2.4
11	2.78	(*b*)	3.05	3.5	2.85	2.0
12	2.78	(*b*)	3.05	3.5	2.75	(*c*)
13	2.65	(*b*)	3.05	3.5	2.7	.....
14	2.62	(*b*)	3.05	3.5	2.65	.....
15	2.68	(*b*)	3.05	3.5	2.65	.....
16	2.65	(*b*)	3.05	3.5	2.9	.....
17	2.58	1.5	3.05	3.5	2.8	.....
18	2.7	1.65	3.02	3.5	2.7	.....
19	2.68	2.65	2.95	3.35	1.75	.....
20	2.72	2.8	2.85	3.2	1.8	.....
21	2.58	2.8	2.98	3.2	1.7	.....
22	2.92	2.8	3.18	3.2	1.65	.....
23	3.1	2.75	3.2	3.2	2.05	.....
24	3.1	2.7	3.12	3.2	2.1	.....
25	3.2	2.8	3.15	3.35	2.1	.....
26	3.2	2.8	3.1	3.5	2.2	.....
27	3.28	2.5	2.55	3.5	2.2	.....
28	3.1	2.5	2.62	3.5	2.25	.....
29	3.1	2.5	3.4	3.45	2.32	.....
30	3.1	2.5	3.4	3.4	2.5	.....
31	3.1	.....	3.3	3.4	.....	.....

[a] Water turned into canal for irrigation.
[b] Water turned out of canal on account of break. No appreciable discharge below 1.50 gage.
[c] Water turned out of canal for season.

CROW CREEK NEAR BELLE FOURCHE, S. DAK.

This station was established May 5, 1904, by F. M. Madden as a flood station. It is located at the highway bridge on the Camp Crook road, about 2½ miles north of Belle Fourche, S. Dak. A plain vertical staff gage is driven into the bed of the stream and the upper end is attached to a tree, a short distance below the bridge on the left bank. It is read only at the time of making discharge measurements. Discharge measurements are made from the bridge or by wading when the water is low. The initial point for soundings is a large spike driven into the downstream hand rail directly over the right pile bent. It is numbered 20 to avoid the minus sign in high water ratings. The channel is straight for about 50 feet above and 100 feet below the station, and the current is quite swift when the water is running. The right bank is high, and does not overflow. The left bank is of medium height, and overflows during high water. The slopes of both banks have some brush growing upon them. The bed of the stream is composed of soft, thick clay formed by decomposed shale, and is permanent. Bench mark No. 1 is a railroad spike driven near the base of a tree on the left bank, about 70 feet downstream from the bridge and 20 feet from the center of the channel. Its elevation is 11.83 feet above the zero of the gage. Bench mark No. 2 is a railroad spike near the base of a tree on the right bank, about 25 feet downstream from the bridge and 20 feet from the center of the channel. Its elevation is 14.95 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrogapher.

Discharge measurements of Crow Creek near Belle Fourche, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 3	F. C. Magruder	27	118	2.86	6.75	338
June 5	do	38	249	3.51	10.85	874

INDIAN CREEK NEAR BELLE FOURCHE, S. DAK.

This station was established May 6, 1904, by F. M. Madden as a flood station. It is located at the highway bridge near Ross's ranch, on the road through Owl Creek reservoir site, Belle Fourche project, and across Owl Creek, about 20 miles northeast of Belle Fourche, S. Dak. The gage is a plain vertical staff, graduated to feet and tenths, in two sections. The lower section is driven into the bed of the stream, projecting about 2 feet, and the upper section is spiked to a pile of the bridge. The gage is read during flood stages, when it is possible to get an observer. Discharge measurements are made by

wading, or from the bridge to which the gage is attached. The initial point for soundings is a spike driven into the right end of the downstream hand rail. The channel is straight for about 40 feet above and 150 feet below the station. The current is sluggish. Both banks are low, covered with a dense growth of brush and occasional trees, and subject to overflow. The bed of the stream is composed of mud, free from vegetation in the bottom of the channel, and is permanent. There is but little water flowing except at flood stages. Bench mark No. 1 is a railroad spike driven into the side of a stump toward the bridge, about 2 feet above the ground, on the right bank, 200 feet above the bridge, near the fence along the road. Its elevation is 11.65 feet above the zero of the gage. Bench mark No. 2 is a railroad spike driven near the base of a tree on the left bank, about 100 feet below the bridge. Its elevation is 13.94 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of Indian Creek near Belle Fourche, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 5	F. M. Madden	9	2.7	0.74	3.0	2.0
May 26[a]	F. C. Magruder	46	20.1	1.18	9.5	23.7

[a] Float measurement.

Mean daily gage height, in feet, of Indian Creek near Belle Fourche, S. Dak., for 1904.

Day.	May.	June.	Day.	May.	June.	Day.	May.	June.
1			12		5.50	23		
2			13		3.88	24		4.00
3			14		3.12	25		3.88
4		10.75	15		3.00	26	8.75	3.12
5		13.75	16			27	5.25	
6		14.75	17			28	3.50	
7		10.75	18			29	3.50	
8		9.25	19			30	3.00	
9		12.00	20			31	3.00	
10		13.88	21					
11		8.62	22					

NOTE.—No water running except on dates when gage height is given.

WHITE RIVER NEAR INTERIOR, S. DAK.

This station was established June 24, 1904, by F. M. Madden. It is located at the ford, about one-fourth mile northeast of Interior, S. Dak. An inclined gage, in two sections, is attached to posts set into the bed of the stream, at edge of bank, and into left bank of the stream. The inclined gage is graduated to read direct to feet and

tenths, and is read once each day by George L. Johnson. Discharge measurements are made by wading at the gage. The initial point for soundings is a spike holding the upper end of the gage to a cottonwood stump. The channel is curved for about 1,000 feet above and 500 feet below the station, and the current is sluggish. Both banks are high, clean, and do not overflow. The bed of the stream is composed of sand and gravel, and is shifting in character. There is but one channel at all stages, except very low water, when there may be several. The slope at the station is about 3 feet per mile. Bench mark No. 1 is a large spike driven into a blaze on a cottonwood tree 30 feet upstream from the gage, on the left bank. Its elevation is 10.41 feet above the zero of the gage. Bench mark No. 2 is a large spike driven into a blaze on a cottonwood tree on the left bank, 50 feet upstream from the gage. Its elevation is 10.26 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of R. F. Walter, resident hydrographer.

Discharge measurements of White River near Interior, S. Dak., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 24	F. M. Madden	112	56	1.41	1.90	79
August 11[a]	do	16	7.9	1.20	1.55	9.5
September 21[a]	do	15	5.8	.81	1.55	4.7

[a] At different sections.

Mean daily gage height, in feet, of White River near Interior, S. Dak., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		1.75	1.6	6.5	1.7	1.65
2		1.7	1.6	4.1	1.7	1.65
3		2.5	1.6	2.8	1.7	1.5
4		3.0	1.9	2.1	1.6	1.5
5		2.3	1.7	2.0	1.9	1.5
6		4.3	1.9	2.2	1.7	1.5
7		3.7	1.85	2.2	1.8	1.5
8		2.45	1.7	2.3	1.7	1.5
9		2.4	1.6	2.0	1.7	1.6
10		2.3	1.6	1.9	1.7	1.6
11		2.4	1.55	1.8	1.7	1.7
12		3.1	1.5	1.8	1.7	1.8
13		3.1	1.5	1.7	2.3	1.75
14		3.2	1.5	1.7	1.9	1.8
15		2.7	1.4	1.6	1.9	1.8
16		2.1	1.4	1.6	1.9	1.85
17		2.1	2.15	1.6	1.85	1.9
18		2.6	2.5	1.6	1.85	1.9
19		2.0	1.95	1.6	1.8	1.9

Mean daily gage height, in feet, of White River near Interior, S. Dak., for 1904—Continued.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
20	.....	2.0	1.8	1.6	1.8	1.85
21	.....	2.4	1.6	1.55	1.8	1.9
22	.....	2.2	1.5	1.55	1.8	1.9
23	.....	2.0	1.4	1.6	1.75	1.9
24	1.9	1.8	1.3	1.6	1.7	1.9
25	1.9	2.2	1.25	1.6	1.7	1.95
26	1.9	1.8	1.2	1.7	1.7	1.95
27	1.85	1.7	1.15	1.6	1.7	1.9
28	1.8	1.7	1.1	1.6	1.7	1.85
29	1.7	1.7	1.2	1.6	1.7	1.8
30	1.7	1.8	2.3	1.6	1.7	1.8
31	.....	1.7	2.1	.....	1.65	.....

NIOBRARA RIVER NEAR VALENTINE, NEBR.

This station was established July 22, 1897, by O. V. P. Stout, and was known as the Fort Niobrara station. On June 26, 1901, it was moved to the Borman Bridge, which is about 3 miles farther upstream. The gage is of the wire and weight type, located about 1,000 feet upstream from the bridge on the left bank. The wire runs over a pulley supported by a frame, on the arm of which the gage heights are read from a scale graduated to half tenths. The distance from the end of the weight to the index or marker on the wire is 9.90 feet. Measurements are made from a one-span steel bridge resting on tubular concrete piers, none of which obstruct the channel. The upstream hand rail is marked at 10-foot intervals, and the initial point for soundings is the zero mark on the upstream hand rail in line with the west face of the east pier. The channel is straight for about 100 feet both above and below the gaging section. The banks are high and not liable to overflow, while the bed is rock, covered at times with a thin layer of shifting sand. The velocity of the water is always very high. The range of gage heights seldom exceeds 1 foot, and the stream has a marked constancy of flow. In spite of the fact that conditions at this station are above the average in their approach to the ideal, it has been difficult to find a stable relation between gage height and discharge. Individual measurements, as determined by a series of duplicate gagings, can be made with a high degree of accuracy, yet it has been necessary to resort to the method of applying corrections to gage heights as outlined in the Nineteenth Annual Report of the United States Geological Survey, Part IV, page 323, et seq., in the preparation of tables of daily discharge. Bench mark No. 1 is the head of a nail driven in the stump of a box-elder tree—one of a clump of four—just east of Mr. Borman's house. Its elevation above gage datum is 17.26 feet. Bench mark No. 2 is a 6 by 6 inch pine head block, on which the gate rests when closed. Its elevation is 16.19 feet above gage datum.

The observations at this station during 1904 have been made under the direction of J. C. Stevens, resident hydrographer.

Discharge measurements of Niobrara River near Valentine, Nebr., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 17	J. C. Stevens	120	179	3.82	1.57	683
April 17	do	117	178	3.60	1.57	640
July 11	do	115	197	3.86	1.44	761
July 11	do	115	197	4.07	1.53	801
July 11	do	115	189	4.02	1.47	760
July 11	do	115	184	4.09	1.51	752
July 11	do	114	194	3.90	1.48	756
August 11	do	110	159	3.67	1.26	584
August 24	do	110	169	3.77	1.30	638

Mean daily gage height, in feet, of Niobrara River near Valentine, Nebr., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.65	2.30	2.05	1.56	1.55	1.86	1.35	1.30	1.54	1.51	1.55	1.54
2	1.74	2.25	1.90	1.53	1.60	1.78	1.35	1.60	1.36	1.50	1.52	1.51
3	1.63	2.35	1.55	1.55	1.55	2.05	1.37	1.33	1.37	1.55	1.53	1.50
4	1.67	2.15	1.80	1.57	1.75	1.85	1.40	1.40	1.49	1.53	1.55	1.58
5	1.68	2.25	1.75	1.60	1.70	1.58	1.92	1.38	1.50	1.52	1.54	1.51
6	1.75	2.40	2.02	1.56	1.65	1.55	1.50	1.40	1.38	1.45	1.57	1.56
7	1.80	1.95	1.87	1.58	1.57	1.55	1.80	1.32	1.40	1.36	1.55	1.65
8	1.80	1.82	1.80	1.60	1.72	1.85	1.53	1.30	1.39	1.38	1.52	1.64
9	1.76	1.80	1.70	1.56	1.60	2.30	1.42	1.31	1.37	1.42	1.56	1.60
10	1.73	1.95	1.78	1.60	1.56	1.60	1.40	1.30	1.34	1.47	1.60	1.66
11	1.70	1.83	1.67	1.60	1.52	1.61	1.55	1.25	1.36	1.48	1.58	1.61
12	1.74	1.96	1.65	1.55	1.72	1.57	1.47	1.29	1.35	1.45	1.55	1.55
13	1.73	2.36	1.60	1.56	1.60	1.55	1.45	1.30	1.35	1.46	1.54	1.56
14	1.74	2.32	1.62	1.60	1.55	1.45	1.42	1.35	1.25	1.43	1.52	1.67
15	1.75	1.96	1.58	1.58	1.51	1.54	1.42	1.24	1.30	1.41	1.55	1.60
16	1.71	2.00	1.60	1.58	1.52	1.50	1.31	1.30	1.26	1.48	1.53	1.71
17	1.70	2.28	1.60	1.58	1.49	1.42	1.32	1.35	1.28	1.43	1.52	1.65
18	1.75	2.20	1.57	1.55	1.51	1.40	1.30	1.33	1.30	1.62	1.56	1.72
19	1.66	2.25	1.55	1.50	1.48	1.47	1.31	1.44	1.36	1.63	1.57	1.57
20	1.61	2.32	1.55	1.49	1.50	1.70	1.26	1.40	1.35	1.55	1.52	1.64
21	1.56	2.31	1.58	1.53	1.52	1.46	1.37	1.36	1.26	1.54	1.58	1.72
22	1.60	2.40	1.50	1.62	1.50	1.42	1.32	1.34	1.30	1.56	1.51	1.78
23	1.61	2.42	1.41	1.55	1.52	1.45	1.30	1.30	1.32	1.54	1.54	1.74
24	1.40	2.20	1.52	1.63	1.50	1.35	1.23	1.31	1.33	1.54	1.53	1.77
25	.95	2.15	1.53	1.60	1.51	1.51	1.32	1.27	1.36	1.53	1.48	1.72
26	1.45	2.20	1.39	1.58	1.45	1.41	1.27	1.25	1.35	1.51	1.54	1.10
27	1.72	2.23	1.52	1.61	1.47	1.35	1.34	1.26	1.37	1.50	1.53	1.40
28	2.15	2.32	1.58	1.50	1.45	1.36	1.37	1.35	1.42	1.55	1.60	1.85
29	2.25	2.15	1.60	1.57	1.45	1.38	1.30	1.35	1.40	1.57	1.54	1.75
30	2.20	.....	1.55	1.55	1.46	1.36	1.35	1.32	1.45	1.58	1.56	1.30
31	2.55	.....	1.62	.....	1.48	.....	1.32	1.34	.....	1.54	.....	2.20

Mean daily discharge,[a] in second-feet, of Niobrara River near Valentine, Nebr., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	615	600	600	655	700	1,155	615	615	805	750	805	805
2	700	600	865	655	750	1,075	615	930	615	750	750	750
3	615	600	550	655	700	1,525	615	655	615	805	805	750
4	615	600	750	655	930	1,155	655	700	750	805	805	865
5	655	600	700	700	865	805	1,330	700	750	750	805	865
6	700	600	1,000	655	805	750	750	700	655	700	805	805
7	750	600	865	700	700	750	1,155	615	655	615	805	865
8	750	750	805	700	865	1,155	805	615	655	655	750	930
9	700	750	615	655	750	2,115	655	615	615	655	805	865
10	700	930	865	700	655	805	655	615	615	700	865	930
11	655	805	700	700	655	805	805	580	615	750	865	865
12	700	930	700	655	865	750	700	615	615	700	805	805
13	700	600	655	655	750	750	700	615	615	700	805	805
14	700	600	655	700	700	655	655	655	550	700	750	930
15	700	600	700	700	655	750	655	580	580	655	805	865
16	655	600	700	700	655	700	580	615	550	750	805	800
17	655	600	700	700	655	615	580	700	580	700	750	800
18	700	600	655	655	655	615	580	700	580	865	805	800
19	615	600	655	615	655	655	580	750	615	930	805	800
20	580	600	655	615	655	930	550	700	615	805	750	800
21	550	600	700	655	655	655	615	655	550	805	865	800
22	580	600	615	700	655	615	580	655	580	805	750	800
23	580	600	550	655	655	655	580	615	580	805	805	800
24	490	600	615	750	655	615	550	615	615	805	805	800
25	450	600	655	700	655	750	580	580	615	805	750	800
26	505	600	550	700	655	655	580	580	615	750	805	800
27	655	600	615	700	655	615	655	580	615	750	805	800
28	600	600	700	615	655	615	655	615	655	805	865	800
29	600	600	700	655	655	655	615	615	655	805	805	800
30	600	.....	655	655	655	615	655	580	700	865	805	800
31	600	.....	700	.....	700	.....	615	615	.....	805	.....	800

[a] The daily discharges were obtained by the indirect method outlined in the Nineteenth Annual Report United States Geological Survey. Pt. iv, p. 323, *et seq.*

Estimated monthly discharge of Niobrara River near Valentine, Nebr., for 1904.

[Drainage area, 6,070 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	750	450	634	38,980	0.104	0.120
February	930	600	640	36,810	.105	.113
March	1,000	550	692	42,550	.114	.131
April	750	615	674	40,110	.111	.124
May	930	655	705	43,350	.116	.134
June	2,115	615	832	49,510	.137	.153
July	1,330	550	675	41,500	.111	.128
August	930	580	644	39,600	.106	.122
September	805	550	627	37,310	.103	.115
October	930	615	760	46,730	.125	.144
November	865	750	800	47,600	.132	.147
December	930	750	823	50,600	.136	.157
The year	2,115	450	709	514,600	.117	1.59

RED DEER LAKE NEAR WOODLAKE, NEBR.

This station was established August 12, 1904, by J. C. Stevens. The lake is located in sections 16, 17, 20, and 21, T. 30 N., R. 27 W., about 16 miles southwest of Woodlake post-office, and about 30 miles south of Valentine, Nebr., and is representative of the numerous lakes abounding in this region. It was established in order to determine the amount of periodic rises of these lakes and their probable cause, which, according to local authorities, is often several feet, beginning in April or May. A plain staff gage, graduated to feet and tenths, is fastened to a post at the end of the boat landing, 200 yards south of Cochran's ranch house near the east end of the lake. The gage is read once each week by J. S. Brosius. The lake covers about 1 square mile of surface and has a varying depth of from 1 to 15 feet—probably an average depth of 8 feet—and is only a valley or flat in the sand hills filled with water. Its bed is entirely of sand and the margin is thickly grown up with rushes, etc. The bench mark is a group of 3 spikes driven horizontally near the base of a cottonwood tree 12 inches in diameter, located 40 feet south and 20 feet east of the southwest corner post of the large windmill tower just west of Cochran's house. Its elevation is 9.61 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of J. C. Stevens, resident hydrographer.

Mean daily gage height, in feet, of Red Deer Lake near Woodlake, Nebr., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1						17		3.50			4.34
2		4.6				18					
3					4.32	19	4.5			4.33	
4				4.32		20					
5						21			4.35		
6						22					
7			4.33			23		4.31			
8						24					4.32
9						25				4.32	
10		4.42			4.34	26					
11						27	4.32				
12				4.33		28			4.32		
13						29					
14			4.31			30		4.36			4.38
15						31					
16											

OSAGE[a] RIVER AT OTTAWA, KANS.

This station was established August 26, 1902, by W. G. Russell. It is located at the highway bridge near the center of the town of Ottawa, Kans. The gage is of the old wire type, with its scale spiked to the bridge floor. This gage was destroyed by the flood of May 30, 1904. A temporary gage was put in June 3, 1904, but which could not be referred to the bench mark as it was under water at that time. This gage was corrected by reference to the bench mark July 18, 1904, and all intermediate gage readings corrected. A new gage was put in September 9, 1904, as the water had left the temporary gage. This is a standard chain gage locked in a box on the outside of the hand rail on the downstream side of the bridge. This gage rod is 1 by 4 inches by 32 feet, painted white, bolted to the hand rail, and is graduated in feet and tenths from zero to 32 feet. It is read once each day by W. H. Blacksten. Discharge measurements are made from the highway bridge, to which the gage is attached. The bridge is somewhat oblique to the thread of the stream and has a total span between abutments of 135 feet. At low stages the discharge can be measured by wading at a short distance below the bridge. The channel is slightly curved and the current is swift. Both banks are high and the bed of the stream is rocky.

The observations at this station during 1904 have been made under the direction of W. G. Russell, resident hydrographer.

[a] Known also as Marais des Cygnes.

Discharge measurements of Osage River at Ottawa, Kans., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 17	W. G. Russell	125	134	5.52	2.30	740
April 29	do	130	225	5.48	3.00	1,230
June 3	do	140	3,165	3.55	23.70	11,230
June 3	do	140	3,290	3.76	24.62	12,310
July 18	do		217	2.04	2.18	443
September 10	do	86	88	1.26	1.60	111

Mean daily gage height, in feet, of Osage River at Ottawa, Kans., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.8	2.0	1.8	2.4	2.8	.....	8.3	1.7	1.4	1.5	1.1	1.3
2	1.9	2.0	1.8	2.3	2.6	.....	5.85	1.7	12.55	1.5	1.2	1.3
3	1.9	2.0	1.9	2.2	2.5	24.6	6.1	1.6	13.3	1.5	1.2	1.3
4	1.9	2.0	1.9	2.2	2.4	24.75	7.35	1.6	2.7	1.5	1.2	1.3
5	1.9	1.9	1.9	2.1	5.8	24.45	4.95	1.6	1.9	1.5	1.2	1.3
6	1.9	1.7	1.9	2.1	13.5	17.0	19.6	1.6	1.7	1.4	1.2	1.3
7	1.9	1.7	1.8	2.2	13.75	5.97	25.55	1.5	1.6	1.4	1.2	1.3
8	1.8	1.8	1.8	2.4	7.8	3.25	30.15	1.5	1.6	1.3	1.2	1.3
9	1.8	1.8	1.8	2.8	9.55	2.85	29.5	1.5	1.6	1.3	1.2	1.3
10	1.8	1.8	1.8	3.0	5.6	2.7	27.25	1.5	1.6	1.3	1.2	1.3
11	1.8	1.8	1.8	3.3	3.2	4.6	17.45	1.5	1.6	1.3	1.2	1.3
12	1.7	1.7	1.8	2.9	2.8	7.85	4.65	1.5	1.6	1.3	1.2	1.3
13	1.7	1.7	1.8	2.7	3.3	3.2	3.25	1.5	1.6	1.3	1.2	1.3
14	1.8	1.6	1.9	2.4	4.9	2.6	2.85	2.1	1.6	1.3	1.2	1.3
15	1.8	1.6	1.9	2.3	3.1	2.7	2.6	1.5	1.6	1.3	1.2	1.3
16	1.8	1.7	1.9	2.2	20.35	7.5	2.3	1.5	1.5	1.2	1.2	1.3
17	1.8	1.7	2.0	2.1	24.25	4.0	2.3	1.5	1.5	1.2	1.3	1.3
18	1.8	1.7	3.0	2.1	23.5	2.8	2.2	1.5	1.5	1.2	1.3	1.3
19	1.8	1.8	2.8	2.0	9.15	12.6	2.0	3.1	1.4	1.2	1.3	1.3
20	1.8	1.7	2.4	2.1	3.4	15.05	2.0	2.5	1.4	1.2	1.3	1.3
21	2.0	1.8	2.4	4.3	3.1	10.5	2.0	2.1	1.3	1.2	1.3	1.3
22	2.2	1.8	4.0	3.7	2.9	6.3	3.5	2.0	1.3	1.2	1.2	1.3
23	2.1	1.7	3.0	4.5	2.7	4.15	2.3	5.0	1.4	1.2	1.2	1.3
24	1.8	1.7	2.5	19.0	2.5	2.65	1.9	2.5	1.4	1.2	1.3	1.3
25	2.2	1.7	11.1	24.15	2.4	16.45	1.8	1.9	1.3	1.1	1.3	1.3
26	2.1	1.8	16.6	20.9	7.0	22.9	2.5	1.9	1.3	1.1	1.3	1.1
27	2.1	1.8	12.0	9.9	9.4	26.25	2.2	1.7	1.3	1.1	1.3	1.1
28	2.1	1.7	3.2	4.1	4.9	25.0	2.1	1.5	1.3	1.1	1.3	1.1
29	2.1	1.7	2.7	3.1	(*b*)	10.4	2.6	1.5	1.3	1.1	1.3	1.1
30	2.1	.....	2.6	2.7	31.8	8.3	1.9	1.5	1.4	1.1	1.3	1.2
31	2.1	.....	2.5	.....	.....	.....	1.8	1.4	.....	1.1	.....	1.3

GASCONADE RIVER NEAR ARLINGTON, MO.

This station was established April 11, 1903, by I. W. McConnell. It is located about 2 miles below Arlington, at the foot of the first bluff near the river on the right bank below the city. The gage is a

vertical 2 by 4 inch rod 16 feet long, fastened to a leaning willow tree. It was read once each day during 1904 by C. W. Harrison. Discharge measurements are made from a cable and boat, with distances marked on a tag wire. On account of the cable being washed away by floods an apparatus for raising and lowering the cable was established November 28, 1903. The elevation of the gage was verified at this time. The initial point for soundings is a blazed white-oak tree 50 feet up the bank from the gage in the line of the cross section. The bench mark to which the gage is referred is a cross on a rock near the same tree, and is at an elevation of 27.2 feet above the zero of the gage. The channel is straight for 500 feet above and 2,000 feet below the station. The current is swift. The right bank is high and wooded to the edge of the cliff, which rises for a vertical distance of 200 to 250 feet. The left bank is low, but not likely to be overflowed except at extreme flood stages. The bed of the stream is of gravel and bed rock, with occasional bowlders, and is not likely to shift. There is but one channel at all stages. At ordinary stages the water is about 10 feet deep.

Owing to the impossibility of maintaining a cable across the river during high water, this station was moved, August 11, 1904, to the St. Louis and San Francisco Railroad bridge, 1¼ miles upstream from the cable and one-fourth mile west of Arlington. This bridge is a three-span Pratt truss, having a total length of 431 feet between abutments. The channel is straight for about 1,000 feet above and below the bridge. There is a swift direct current. Both banks are fairly high and partially wooded, and are subject to overflow only during very high water. At all stages the water passes between the abutments of the bridge. The bed of the stream is composed of clean gravel and rock and is practically permanent. A regulation chain gage is used, having a length of weight and chain to the outside of the ring (which is used for marker) of 33.50 feet. The pulley center is 0.53 foot to the left of the zero of the gage. The zero of the gage is at 117.01 feet from the initial point for soundings, which is situated on the inner face of the right abutment. The bench mark is located on the top surface of a cap situated on the upstream lower chord just to the right of the fifth panel point from the right abutment. This is designated by a dent in the upper surface of the above-mentioned cap. Its elevation is 28.85 feet above the gage datum. The elevation above the zero of the gage of the pulley center is 32.75 feet.

The observations at this station during 1904 were under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Gasconade River near Arlington, Mo., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
January 26	F. W. Hanna	295	2,277	2.08	6.49	4,734
March 7	do	264	1,496	1.14	3.75	1,713
April 11 [a]	do	410	2,415	3.32	8.00	8,025
April 27 [a]	do	410	4,029	4.20	11.70	16,910
June 14 [a b]	Hanna and Murphy	410	1,138	1.78	[b] 4.30	2,032
July 26 [c]	F. W. Hanna	294	1,006	1.39	3.55	1,403
August 11 [c]	do	269	847	1.02	3.10	864
September 27 [c]	Hanna and Johnson	269	835	.95	3.08	794
November 25 [c]	F. W. Hanna	236	709	.85	2.83	600

[a] Frisco Railroad bridge.
[b] Gage doubtful, as it was loosened by the flood.
[c] New gage with new gage-datum plane.

Mean daily gage height, in feet, of Gasconade River near Arlington, Mo., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.9	4.1	4.5	9.0	6.9	4.5	8.5	3.3	3.2	3.3	2.7	2.8
2	2.9	3.8	4.1	9.0	6.4	4.3	6.5	3.2	3.3	3.35	2.75	2.85
3	2.9	3.8	4.1	8.0	6.0	4.2	6.0	3.2	3.3	3.3	2.7	2.8
4	2.9	3.85	4.0	8.0	5.8	9.3	6.5	3.1	3.2	3.15	2.65	2.7
5	2.7	3.7	3.9	7.0	5.7	10.0	6.7	3.1	3.2	3.1	2.65	2.7
6	2.6	3.6	3.8	6.05	5.7	10.1	6.4	3.0	3.1	3.05	2.65	2.6
7	2.5	3.6	3.6	6.0	5.8	10.0	5.7	2.9	3.0	3.0	2.65	2.65
8	2.5	3.55	3.6	8.0	5.9	7.0	5.4	2.8	3.1	3.0	2.7	2.6
9	2.5	3.5	4.6	9.05	6.4	6.5	5.5	3.1	3.0	2.95	2.75	2.65
10	2.5	3.5	4.6	9.05	5.8	5.5	4.9	2.9	3.0	3.0	2.8	2.85
11	2.5	3.5	4.6	8.0	5.6	5.5	4.7	2.9	3.0	2.9	2.75	2.85
12	2.5	3.4	4.6	7.5	5.5	4.8	4.4	[b] 2.85	2.95	2.95	2.7	2.9
13	2.5	3.3	4.6	6.8	5.3	4.5	4.2	2.9	3.0	2.95	2.6	2.85
14	2.5	3.2	4.5	6.4	5.0	4.3	4.0	3.0	3.2	2.9	2.6	2.85
15	2.5	3.1	3.9	6.0	4.8	4.1	3.9	3.1	3.55	2.9	2.6	2.8
16	2.5	3.1	3.8	5.9	4.8	4.5	3.7	3.15	3.2	2.9	2.65	2.8
17	2.5	3.05	3.9	6.5	4.8	4.3	3.5	3.1	3.1	2.9	2.65	2.85
18	2.5	3.0	4.0	5.9	5.5	4.2	3.5	3.0	3.0	2.9	2.6	2.85
19	2.4	2.9	4.1	5.2	5.4	4.5	3.5	3.1	3.4	2.9	2.7	2.9
20	2.4	2.9	4.1	5.1	5.0	6.3	3.4	3.3	3.35	2.9	2.7	2.95
21	10.7	3.3	4.2	5.9	4.05	5.3	3.3	3.2	3.1	2.95	2.65	2.85
22	10.7	3.8	4.2	7.1	4.3	5.0	3.2	3.8	3.1	2.9	2.6	2.85
23	11.5	3.9	4.2	7.2	4.2	6.0	3.2	4.65	3.1	2.8	2.6	2.85
24	10.5	3.9	4.5	(a)	4.2	5.3	3.1	4.95	3.1	2.8	2.6	2.85
25	7.7	4.1	5.5	(a)	4.2	5.2	3.0	5.0	3.1	2.8	2.9	2.95
26	6.4	4.5	16.5	18.0	5.0	14.5	3.5	4.1	3.05	2.8	2.85	2.95
27	6.3	4.9	(a)	14.2	4.4	14.0	3.4	3.85	3.0	2.8	2.85	2.90
28	5.3	4.8	(a)	10.5	4.0	14.3	3.4	3.6	3.05	2.85	2.8	2.90
29	5.0	4.7	(a)	8.3	6.0	10.0	3.3	3.5	3.0	2.8	2.8	2.85
30	4.7	.....	9.0	7.5	5.5	8.0	3.3	3.4	3.2	2.7	2.8	2.8
31	4.5	.....	9.0	.....	5.4	.....	3.2	3.3	.....	2.7	.....	2.85

[a] Over gage.
[b] Beginning August 12 the gage heights refer to the new datum of the chain gage established at the St. Louis and San Francisco Railroad bridge.

Rating table for Gasconade River near Arlington, Mo., from January 1, 1903, to August 11, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.30	815	4.00	1,930	5.60	3,920	8.40	8,890
2.40	849	4.10	2,041	5.70	4,055	8.60	9,326
2.50	885	4.20	2,155	5.80	4,191	8.80	9,762
2.60	923	4.30	2,271	5.90	4,328	9.00	10,200
2.70	963	4.40	2,390	6.00	4,467	9.50	11,350
2.80	1,006	4.50	2,510	6.20	4,751	10.00	12,550
2.90	1,052	4.60	2,632	6.40	5,051	10.50	13,800
3.00	1,100	4.70	2,755	6.60	5,367	11.00	15,090
3.10	1,152	4.80	2,879	6.80	5,699	11.50	16,390
3.20	1,210	4.90	3,004	7.00	6,047	12.00	17,740
3.30	1,276	5.00	3,130	7.20	6,411	13.00	20,440
3.40	1,349	5.10	3,258	7.40	6,790	14.00	23,140
3.50	1,430	5.20	3,388	7.60	7,184	15.00	25,840
3.60	1,519	5.30	3,519	7.80	7,594	16.00	28,540
3.70	1,615	5.40	3,651	8.00	8,018	17.00	31,240
3.80	1,716	5.50	3,785	8.20	8,454	18.00	33,940
3.90	1,821						

The above table is applicable only for open-channel conditions. It is based upon 14 discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.4 feet and 6.1 feet. The table has been extended beyond these limits. Above gage height 11.5 feet the rating curve is a tangent, the difference being 270 per tenth. On August 11, 1904, the station was changed to the St. Louis and San Francisco Railway bridge, and a gage with a new datum installed. Gagings on that and succeeding dates are not applicable to this curve.

Estimated monthly discharge of Gasconade River near Arlington, Mo., for 1904.

[Drainage area, 2,725 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	16,390	849	3,435	1.26	1.45
February	3,004	1,052	1,653	.607	.655
March, 28 days [a]	.....	1,519	3,757	1.38	1.44
April, 28 days [a]	.....	3,258	8,390	3.08	3.21
May	5,871	1,930	3,519	1.29	1.49
June	24,490	2,041	6,959	2.55	2.84
July	9,108	1,100	2,620	.961	1.11
August, 11 days [b]	1,276	1,006	1,129	.414	.169

[a] For three days in March and two in April the water was over the gage.
[b] August 12 the gage was changed to a new location with a new datum.

MISCELLANEOUS MEASUREMENTS IN MISSOURI RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in Missouri River drainage basin in 1904:

Miscellaneous measurements in the Missouri River drainage basin in South Dakota and Montana.

Date.	Stream.	Locality.	Area of section.	Mean velocity.	Gage height.	Discharge.
			Sq. feet.	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
Mar. 30	Spearfish Creek	Spearfish, S. Dak	24	2.67		64
Apr. 14	Spearfish power flume	do	27	1.15		31
Apr. 15	Cottonwood Creek	Edgemont, S. Dak	.6	.67		.40
Apr. 18	Cheyenne River	Mouth of Fall River	58	1.21		70
Apr. 18	Fall River	At mouth	15	1.87		28
Apr. 18	Evans power flume	Hot Springs, S. Dak	18	2.33		42
Apr. 18	Irrigation ditch	⅛ mile below Hot Springs	7.5	2.03		17
Apr. 26	Bad River	Near Midland, S. Dak	2.9	.55		1.6
Apr. 27	White River	Stearns, S. Dak	40	3.82		153
Apr. 30	Cheyenne River	Creston, S. Dak	33	1.70		56
Apr. 30	Rapid Creek	do	28	2.79		78
Apr. 30	Murphy ditch	Hewitt ranch on Rapid Creek, S. Dak.	8.1	2.47		20
May 14	Cottonwood Creek	Edgemont, S. Dak	3.1	.13		.4
May 18	Figel ditch	Rapid, S. Dak	2.2	.32		.7
May 21	Belle Fourche power canal.	Belle Fourche, S. Dak	15	2.00		30
May 26	Cottonwood Creek	Edgemont, S. Dak	31	3.10		94
June 1	Horse Creek	Bixby road, S. Dak	32	.37		12
June 3	Moreau River	Bixby, S. Dak	89	1.54		137
June 7	Rabbit Creek	Seim road, S. Dak	40	2.28		91
June 9	Main Fork Sulphur Creek.	Bixby road, S. Dak	154	1.88		290
July 5	Belle Fourche power canal.	Belle Fourche, S. Dak	14	1.21		17
July 14	North Fork Grand River	Seim, S. Dak	3	1.00		3
Aug. 3	Spearfish power flume	Spearfish, S. Dak	20	1.04		21
Aug. 3	Matthews & Son ditch	do	1.9	3.75		7.1
Aug. 3	Gregg & Matthews ditch	do	2.4	1.31		3.1
Aug. 3	Walton & Co. ditch	do	2.5	2.25		5.7
Aug. 3	Mann ditch	do	2.4	.52		1.2
Aug. 4	Eckles ditch	do	2.2	1.51		3.3
Aug. 4	Evans ditch	do	4	3.00		12
Aug. 4	Cooks ditch	do	12	3.08		37
Aug. 4	Toomeys ditch	do	4.4	1.16		5.1
Aug. 4	McGregors ditch	do	3.9	.94		3.7
Aug. 4	Bill Cook ditch	do	6.1	3.29		20
Aug. 4	Kemper & Dersey ditch	do	7.5	1.49		11.2
Aug. 4	Spearfish Creek	Below Spearfish, S. Dak	25	1.12		29
Aug. 9	Little Grant	Rapid, S. Dak	2.6	2.08		5.4
Aug. 9	Farmingdale ditch	do	2.6	1.73		4.5
Aug. 9	Rapid Creek	Creston, S. Dak	14	1.57		22
Aug. 9	Cheyenne River	do	30	1.60		48
Aug. 13	St. German ditch	Rapid, S. Dak	12	1.25		15
Aug. 13	Lone Tree ditch	do	14	1.50		21
Aug. 13	South ditch	do	8	1.75		14
Sept. 11	Missouri River	Great Falls, Mont	1,174	2.39		2,811
Sept. 11	Giant Springs	do	57	3.54		202

Miscellaneous measurements in the Missouri River drainage basin in South Dakota and Montana—Continued.

SUBDRAINAGE AREA OF MILK RIVER.

Date.	Stream.	Locality.	Area of section.	Mean velocity.	Gage height.	Discharge.
			Sq. feet.	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 15	Milk River	Coutts, Mont	22	2.79		[a] 62
Aug. 9	do	Yantic, Mont	3.8	.76		2.9
Aug. 9	do	Chinook, Mont	4.3	.70		3
Aug. 8	do	Zurich, Mont	3.5	.66		2.3
Aug. 8	do	Fort Belknap Agency, Mont.	2.8	.50		1.4
Aug. 6	do	Glasgow, Mont	9.3	2.96		27.5
Aug. 9	West Fork Milk River	Chinook, Mont	[b]	[b]		2
Apr. 8	Exeter Creek	Exeter, Mont	18	1.11		20
Apr. 13	do	do	[b]	[b]		1
Apr. 18	Alkali Creek	Malta, Mont	153	1.80		[e] 275
Aug. 8	New Fort Belknap canal	Indian Agency	3.1	.64	2.15	[d] 2

SUBDRAINAGE AREA OF YELLOWSTONE RIVER.

July 26	Crow Agency ditch	Crow Agency, Mont	34	0.80		[e] 27
July 26	Little Bighorn River	do	95	1.87		[e] 179
Sept. 17	do	do	[b]	[b]		250
Sept. 28	do	do	70	.93		[e] 65

[a] Near head of Milk River canal of the Canadian Northwest Irrigation Company.
[b] Estimated.
[c] 1 mile above junction with Milk River.
[d] 150 feet below the canal head gates.
[e] Near head gates of Crow Agency ditch.

Streams tributary to Niobrara River in Nebraska.

Date.	Hydrographer.	Stream.	Locality.	Area.	Mean velocity.	Discharge.
				Sq. feet.	*Ft. per sec.*	*Sec.-feet.*
Aug. 19	J. C. Stevens	Bear Creek	Sec. 31, T. 34, R. 34	1	2.00	2
Aug. 16	do	Boardmans Creek	Sec. 1, T. 30, R. 31	6.8	1.07	7.3
Aug. 23	do	Deer Creek	Sec. 5, T. 30, R. 43	3.8	1.92	7.3
Aug. 13	do	Fairfield Creek	Sec. 31, T. 33, R. 23	16	1.34	21.5
July 13	do	Keya Paha River	Butte	92	2.22	204
Oct. 23	Adna Dobson	do	Sec. 24, R. 34, T. 16			78
Aug. 24	J. C. Stevens	Minnechaduza Creek	Valentine	14	1.50	21
July 13	do	Millrace	Electric power plant, Butte.	38	1.40	53
July 13	do	Niobrara River	Butte	430	6.53	2,808
Aug. 13	do	do	Sec. 31, T. 33, R. 23	285	2.64	752
Aug. 14	do	do	Sec. 26, T. 34, R. 26	203	3.34	679
Aug. 18	do	do	Sec. 10, T. 33, R. 34	84	2.63	221
Aug. 20	do	do	Sec. 11, T. 33, R. 36	101	1.98	200
Aug. 20	do	do	Sec. 27, T. 33, R. 37	42	4.33	180
Aug. 21	do	do	Sec. 34, T. 33, R. 38	51	2.29	117
Aug. 22	do	do	Sec. 24, T. 31, R. 42	35	1.54	54
Aug. 23	do	do	Sec. 18, T. 30, R. 43	21	1.30	27
Aug. 13	do	Plum Creek	Sec. 7, T. 31, R. 23	34	2.35	80
Aug. 23	do	Pine Creek	Sec. 22, T. 30, R. 44	13.6	.94	12.8
Aug. 22	do	Rush Creek	Sec. 32, T. 31, R. 42	.3	2.00	.6
Aug. 16	do	Snake River	Sec. 15, T. 32, R. 30	106	2.63	279
Aug. 16	do	do	Sec. 10, T. 30, R. 31	77	2.65	204
Aug. 17	do	do	Sec. 2, T. 30, R. 32	65	2.97	194
Oct. 27	do	do	Sec. 16, T. 31, R. 30	104	2.40	245
June 19	G. W. Bates	White Clay Creek	Sec. 36, T. 35, R. 45			11

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